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ENGINEERING:

An Illustrated Weekly Journal.

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VOL. CXVII.—No. 3040.] LONDON: FRIDAY, APRIL 4, 1924. [Registered at the General Post Office as a Newspaper.] [PRICE ... 1s. BY FOREIGN POST 1s. 3½d.

Aveling & Porter, Ltd., ROCHESTER.

Steam & Crude Oil Rollers.
SPECIAL ROLLERS FOR BITUMINOUS ROADS. 1869

A. G. Mumford, Ltd., CULVER STREET WORKS, COLCHESTER.
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See advertisement page 18.
PATENT WATER-TUBE BOILERS.
AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 3179

Dredging Plant
OF ALL DESCRIPTIONS.
FLOATING CRANES. COAL BUNKERING VESSELS.
Werf Conrad, HAARLEM, HOLLAND.
Agents: MARINE WORKS, LTD., FRIARS HOUSE, 39-41, NEW BROAD ST., LONDON E.C.2.
See half-page Advert. last week and next week. 2087

CRANES. All Types.
GEORGE RUSSELL & CO., LTD., Motherwell. 1867

STEEL TANKS, PIPES, GASHOLDERS, &c.
Thos. Piggott & Co., Limited, BIRMINGHAM. 1241
See Advertisement last week, page 19.

Spencer-Hopwood & Kirke PATENT BOILERS See Page 73. 1293
Sole Makers: SPENCER-BONECOURT, LTD., Parliament Mansions, Victoria St., London, S.W.

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO. LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 1864

P. & W. MacLellan, Ltd., CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF RAILWAY CARRIAGES AND WAGONS OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 129, Trongate, Glasgow. Od 8547
Registered Offices: Clutha House, 10, Princes St., Westminster, S.W.1.

Brett's Patent Lifter Co. LIMITED.
Hammers, Presses, Furnaces, COVENTRY. 610

Invincible Gauge Glasses.
BUTTERWORTH BROS., Ltd., Newton Heath Glass Works, Manchester. Od 9753

For Your Repairs or any SPECIAL MACHINERY, try THOMAS HUNT & SONS, Albion Ironworks, Bridge Road West, Battersea, S.W. 11. Est. 1854. 2007

Fuller, Horsey, Sons & Cassell. SPECIALISTS in the SALE AND VALUATION of PLANT AND MACHINERY and ENGINEERING WORKS. 11, BILLITER SQUARE, E.C.3. 1834

Iron and Steel
Tubes and Fittings.
Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 817
The Scottish Tube Co., Ltd., HEAD OFFICE: 34, Robertson Street, Glasgow. See Advertisement, page 79, March 28.

YARROW & CO. (1922), LTD., GLASGOW.
PASSENGER AND CARGO STEAMERS.
SHALLOW DRAFT VESSELS. 1552

Campbells & Hunter, Ltd.
Gear Cutting.
Worm Wheels cut up to 13 ft. diam.
Bevel and Mitre Wheels planed up to 3 ft. diam.
Spur Wheels cut up to 9 ft. diam.
DOLPHIN FOUNDRY, LEEDS. 4547

VOSPER & Co., LTD., PORTSMOUTH, SHIP & LAUNCH BUILDERS, Od 3551 ENGINEERS & BOILER MAKERS.

THE GLASGOW ROLLING STOCK AND PLANT WORKS.
Hurst, Nelson & Co., Ltd., Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS, and EVERY OTHER DESCRIPTION OF RAILWAY and TRAMWAY ROLLING STOCK.
Makers of WHEELS and AXLES, RAILWAY PLANT, FORGINGS, SMITH WORK, IRON & BRASS CASTINGS, PRESSED STEEL WORK OF ALL KINDS. Od3382
Reg. Office and Chief Works: Motherwell. London Office: 32, Great St. Helens, Bishopsgate, E.C. 3.

OIL FUEL APPLIANCES, Systems PRESSURE, AIR, STEAM
For Boilers of all types.
KERMODES LIMITED, 35, The Temple, Dale Street, Liverpool.
Naval Outfits a Speciality, also for Merchants Ships, for Factories, Locomotives, and Industrial Process Furnaces of all kinds.
Supplied to the British and other Governments.
Telephone No.: Central 2832.
Telegrams: "Warmth." 4078

Locomotives Tank Engines
designed and constructed by MANNING, WARDLE AND COMPANY, LIMITED, Boyne Engine Works, Leeds. Od 2457
See their Illus. Advertisement; page 59, last week.

Gearing of all Descriptions.
GEAR WHEELS up to 10 ft. diameter.
FLY ROPE and SPUR DRIVING WHEELS up to 28 ft. diameter.
BRICK and CLAYWORKING MACHINERY of all kinds.
ENGINES:—"Uniflow," "Corliss," or Drop Valve.
CLAYTON, GOODFELLOW & CO., LTD., Blackburn. 1249

R. Y. Pickering & Co., Ltd. (Established 1864.)
BUILDERS of RAILWAY CARRIAGES & WAGONS
MAKERS of WHEEL and AXLES of all kinds
RAILWAY WAGONS FOR HIRE
Chief Works and Offices: WISHAW, near GLASGOW.
London Office: Od 8353
3, VICTORIA STREET, WESTMINSTER, S.W.

MACHINE CUT
Gears.
Spurs, Bevels.
Spiral, Worm and Worm Wheels.
HIGHFIELD GEAR CUTTING CO. (Dept. H.), Huddersfield. 1645

ON ADMIRALTY LIST.
John Kirkaldy, Ltd.,
London Office: 101, LEADENHALL ST., E.C.3.
Works: BURNT MILL, near HARLOW, ESSEX.
Makers of
Evaporating and Distilling Plants.
Refrigerating and Ice-making Machinery.
Feed Water Heaters.
Evaporators.
Fresh Water Distillers.
Main Feed Pumps.
Combined Circulating and Air Pumps.
Auxiliary Surface Condensers, &c., &c. 1586

John Bellamy, Limited, MILLWALL, LONDON, E. 1216
GENERAL CONSTRUCTIONAL ENGINEERS,
Boilers, Tanks, & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

IRON & STEEL
Tubes AND Fittings AND Steel Plates.
STEWARTS AND LLOYDS, Ltd. GLASGOW BIRMINGHAM LONDON.
See Advertisement, page 90. 1872

Peter Brotherhood Ltd., PETERBOROUGH.
STEAM ENGINES AND TURBINES.
GAS AND OIL ENGINES.
AIR COMPRESSORS.
REFRIGERATING PLANT. 1475
See Advertisement, page 53, March 28.

The Glasgow Railway Engineering Company, GOVAN, GLASGOW. LTD.,
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF RAILWAY CARRIAGE, WAGON & TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORK, also CAST-STEEL AXLE BOXES. 1948

Electric Generating Plant for SALE.
Direct Current.

Two	26 Kw.	105 Volts.	"Howden-B.E.H."
Two	52 ,,	,, ,,	"Brotherhood - Laurence Scott."
Two	100 ,,	440/500 ,,	Gerrett Semi-Portable.
One	120 ,,	110 ,,	"Belliss-Siemens."
One	150 ,,	220 ,,	"Howden-Lanc. Dynamo."
Two	200 ,,	,, ,,	"W. H. ALLEN."
Two	200 ,,	,, ,,	"Belliss-Siemens."
One	240 ,,	440/500 ,,	"Belliss-Phœnix Dynamo."
One	375 ,,	250 ,,	"Allen-Westinghouse."
One	400 ,,	240 ,,	"Howden-Siemens."
One	500 ,,	220 ,,	"Howden-B.T.H."
One	500 ,,	230 ,,	"Belliss-B.T.H."
One	500 ,,	500 ,,	Metropolitan Vickers Turbo.
One	600 ,,	500 ,,	"Belliss-Mather & Platt."
One	750 ,,	220 ,,	"Parsons - Crompton" Geared Turbo.
One	1250 ,,	250 ,,	"Belliss" Turbo.

Alternating Current, 3-Phase, 50 Periods.

One	400 Kw.	500/550 Volts.	"Howden-G.E.C."
One	750 ,,	,, ,,	"Metropolitan-Vickers."
One	850 ,,	,, ,,	"Fraser & Chalmers."
Two	1000 ,,	,, ,,	"Metropolitan-Vickers."
One	1000 ,,	3300 ,,	"B.T.H."
Two	1000 ,,	,, ,,	"Metropolitan-Vickers."
One	2000 ,,	500/550 ,,	"B.T.H."
One	3000 ,,	6600 ,,	"B.T.H." ,,

All above are modern, and condensing plant is available in nearly all cases.
We can also offer several Suction Gas and Diesel Sets, Babcock Boilers up to 30,000 lbs. per hour, and a very large number of motors, generators, Motor-generators, rotary converters, etc.
Enquiries Invited.
THE PHŒNIX ELECTRICAL COMPANY, LTD., 17, OSWALD STREET, GLASGOW. 822

James D. Roots.—Patents, BRITISH and FOREIGN. Moderate charges, Long and varied practical Engineering experience valuable to Inventors. Formerly many years contributor of Patents Abstracts for "The Engineer" & "The Times."—Thanet House, Temple Bar, London, W.C.2.

Telegrams: "Epa," London.
Telephone: 7424 Central.
E. P. Alexander & Son.
CHARTERED PATENT AGENTS,
306, High Holborn, London, W.C. 1. 585
PATENTS. DESIGNS. TRADE MARKS.

EXAMINATION AND PHOTOGRAPHY OF METALS. See F. DAVIDSON & Co's. Advt., page 89.

Royles Limited, ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, } NOW'S PATENTS.
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES.
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5723

YARROW & CO. (1922), LTD., GLASGOW.
LAND AND MARINE
YARROW BOILERS. 1553

Matthew Paul & Co., Ltd. LEVENFORD WORKS, Dumbarton. 1483
See Full Page Advt., page 61, March 28.

Forgings.
Walter Somers, Limited, HALESOWEN. 7116

Taylor & Challen Presses
For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
Foundry, Works, and Showrooms: BIRMINGHAM.
See advert., page 59, March 28. 3195

"Delta" Brand HIGH-CLASS ENGINEERING ALLOYS.
Forgings, Castings, Bars, Sheets, Wire, Tubes.
THE DELTA METAL CO., LTD., 2033
E. GREENWICH, LONDON, S.E. 10 (& at Birmingham)

Railway Switches and Crossings
T. SUMMERSON & SONS, LIMITED, DARLINGTON. 2006

DAVID BROWN & SONS (Hudd.) Ltd. Lockwood Huddersfield.
HIGH CLASS
Machine Cut Gearing
FOR EVERY PURPOSE. 1440

HEAT INSULATION.
CELITE PRODUCTS CORPORATION, Windsor House, Westminster, S.W.1. 1675
See our Illustrated Advertisement, March 14.

E. J. Davis, M.I.Mech.E., Gas Engines Inspected, Tested and Reported upon. Over 25 years' experience. Tel.: Maryland 1736 & 1737. Wire: "Rapidising, London." —Great Eastern Road, Stratford, E.15. 1794

RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd., THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 3383

Rosser and Russell, Ltd., MECHANICAL ENGINEERS, QUEEN'S WHARF, HAMMERSMITH, W.
Undertake SPECIAL MACHINE WORK of any description.
WELL EQUIPPED SHOP.
LATHE WORK up to 10 ft. diameter.
'Phone: Hammersmith 31, 967. 9211

Centrifugals.
Pott, Cassels & Williamson, MOTHERWELL, SCOTLAND. 1676
See half-page Advertisement, page 68, March 14.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. E. STROMEYER, M.I.C.E. Founded 1854 by Sir WILLIAM FAIRBAIRN.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 2005

The Manchester Steam Users' ASSOCIATION.

The ANNUAL GENERAL MEETING of the Members was held in the Board Room of the Association, at their Offices, 9, Mount Street, Manchester, on Tuesday, April 1st, HAROLD LEE, Esq., J.P. (Manchester), President, in the Chair, when the following resolutions were adopted:—

Moved by the CHAIRMAN, seconded by J. T. BROWNE, Esq., Pendlebury (Vice-President), and resolved:—

"That the Report of the Committee of Management to the Subscribers be adopted."

Moved by OSCAR S. HALL, Esq. (Messrs. Robert Hall & Sons, Ltd., Bury), seconded by W. R. GRIFFITHS, Esq. (Peel-Conner Telephone Works Ltd., Salford), and resolved:—

"That the thanks of the Association are due and are hereby presented to the Committee of Management for their past services, and that the following gentlemen be elected the Committee for the ensuing year, with power to add to their number":—

COMMITTEE OF MANAGEMENT.

HAROLD LEE, Esq., J.P., Manchester.
A. NORMAN DUGDALE, Esq., J.P., Blackburn.
JAS. STANLEY ADDISON, Esq., London.
J. T. BROWNE, Esq., Pendlebury.
ALFRED H. J. COCHRANE, Esq., Openshaw.
CHARLES W. CROSSLEY, Esq., J.P., Halifax.
CHARLES ROBERTS, Esq., Manchester.

JAMES PARR,
Secretary.

9, Mount Street, Albert Square, Manchester.
April 2nd, 1924. D 397

University of Liverpool.

FACULTY OF ENGINEERING.

DEAN: Professor T. B. ABELL, O.B.E., M.Eng., R.C.N.C, Ret., M.Inst.,N.A.

The University awards the degrees of B.Eng., M.Eng., D.Eng., Ph.D., and a Certificate and Diploma in Engineering.

Degree candidates must pass an approved Matriculation examination. Candidates for a certificate (which leads to a Diploma) must have (i) been engaged in Practical Engineering, (ii) followed approved courses in a Technical School.

The courses are designed for students desiring to qualify as MECHANICAL, ELECTRICAL, CIVIL or MARINE ENGINEERS, as NAVAL ARCHITECTS and METALLURGISTS or METALLURGICAL ENGINEERS. The Courses cover the subjects of examination for Associate Membership of the Institutions of Civil, Mechanical, and Electrical Engineers. The institutions named, subject to certain conditions, accept the degree of B.Eng. in lieu of part, and in some cases the whole of the examinations for Associate Membership. The various departments are housed in commodious and well-equipped buildings, and provide ample facilities for research.

A prospectus of the Faculty, giving particulars of courses and a large number of Entrance and Post-graduate Scholarships, may be had on application to the undersigned.

EDWARD CAREY,
Registrar. D 348

Correspondence Courses for

Inst.Civil Engrs., Inst.Mech.E., London Univ. (Matric., inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., etc. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 1993

Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of Training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 1879

TENDERS.

BOROUGH OF POOLE.

The Corporation of Poole are prepared to receive

Tenders for the Supply and

CONSTRUCTION of a NEW BRIDGE over the Channel dividing Poole from Hamworthy. The bridge, which will have a total length of 300 feet, will consist of three reinforced concrete spans on each side and one steel opening span of 60 feet clear in the centre of the bridge; this opening span will rest on two piers, each pier being made up of four cylinders varying from 7 feet to 13 feet in diameter with top platform of reinforced concrete.

Plans and draft contract can be seen and the Specification, Schedule of Quantities and Form of Tender obtained at the Offices of the Consulting Engineers, Messrs. LIVESEY, SON & HENDERSON, 14, South Place, London, E.C. 2, on and from Monday the 31st day of March, 1924, between the hours of 10.30 a.m. and Four p.m., upon payment of a deposit of Five guineas, which deposit will be returned upon receipt of a *bona-fide* Tender which is not subsequently withdrawn by the Contractor.

Tenders must be on the official form, each Tender in a sealed envelope marked "Poole Bridge." Tenders must be accompanied by the General Conditions, Specification and Schedule as issued by the Consulting Engineers.

Each Tender must be signed in the handwriting of the Tenderer or his authorised agent.

The Council does not bind itself to accept the lowest or any Tender.

Tenders must reach the undersigned by Nine a.m. on Monday, the 28th of April, 1924.

CHARLES LISBY,
Town Clerk.

Town Clerk's Office,
POOLE, Dorset.
25th March, 1924. D 313

CITY OF BIRMINGHAM.

WATER DEPARTMENT.

SALE OF PUMPING MACHINERY.

Tenders are Invited for the

PURCHASE, DISMANTLING and REMOVAL of PUMPING MACHINERY, BOILERS, etc., at Plant's Brook Pumping Station, near Minworth, Warwickshire, comprising:—

One 200 HP., Compound Differential Pumping Engine, in excellent condition, manufactured by Messrs. Hathorn, Davey & Co., of Leeds.
One 100 HP. Cornish Engine (old).
Four Roots' Boilers (old), steam pipes, etc.

Full particulars, together with Form of Tender and Permit to view, may be had on application to the undersigned.

J. H. BROADLEY,
Secretary.

Water Department,
Council House,
BIRMINGHAM.
26th March, 1924. D 300

COUNTY BOROUGH OF WOLVERHAMPTON.

WATERWORKS UNDERTAKING.

15 in. and 12 in. CAST IRON TRUNK MAINS.

The Wolverhampton Corporation is prepared to receive

Tenders for Providing and

LAYING about 5400 yards of 15 in. and 2950 yards of 12 in. CAST IRON WATER MAINS, and Executing other Work in connection therewith, from Contractors who pay to the whole of their employees such remuneration and observe such hours of employment as are recognised by the Employees' Unions and Associations of Employers in the several localities where the work is done.

A copy of the Specification, Quantities, and Form of Tender may be obtained from Mr. H. A. B. WOODWARD, Waterworks Engineer, Town Hall, Wolverhampton, upon payment of the sum of £2 sterling, which amount will be returned to each Contractor who submits a *bona fide* Tender, but not otherwise.

Each Tender must be enclosed in a sealed envelope, addressed to "The Chairman of the Water Committee," and endorsed "Trunk Mains," and delivered at my Office on or before Ten a.m. on Tuesday the 15th day of April, 1924.

The right to decline the lowest or any Tender is reserved to the Corporation.

F. E. WARBRECK HOWELL,
Town Clerk.

Town Hall, Wolverhampton.
5th March, 1924. D 178

THE MUNICIPALITY OF SINGAPORE.

TENDER FOR STEEL PIPES, VALVES, &c.

Sealed Tenders, Addressed to

Messrs. C. C. LINDSAY & PEIRCE, 180, Hope Street, Glasgow (Agents to the Municipality of Singapore), endorsed "Singapore Municipality. Tender for Steel Pipes, Valves, etc." will be received until Five p.m. on Wednesday the 23rd April, 1924, for the SUPPLY and DELIVERY at Singapore of about 4¼ MILES OF WELDED STEEL PIPE, 33 inches internal diameter; about 4¼ miles of WELDED STEEL PIPE, 36 inches internal diameter; about four miles of WELDED STEEL PIPE, 39 inches internal diameter, together with certain Cast Iron Pipes, Valves and Specials. Though Lap Welded Steel Pipes are specified, Tenderers are at liberty to offer other makes of Steel Pipes, but rivetted pipes will not be accepted, and whatever make of pipe may be offered must be of British material and manufacture.

Forms of Tender and Specification may be obtained from Sir ALEX. BINNIE, SON & DEACON, 30, Buckingham Gate, Westminster, S.W.1, or from the Agents to the Municipality on receipt by either of them of a cheque to the value of £5 made out to the Agents, Messrs. C. C. LINDSAY & PEIRCE, which amount will be returned on receipt of a *bona fide* Tender. Drawings may be seen at the Offices of Messrs. Sir Alex. Binnie, Son & Deacon.

The lowest or any Tender will not necessarily be accepted nor will any expenses in connection with tendering be defrayed. No Tenders will be considered except from actual Manufacturers, capable of supplying the pipes at the rate of 100 of each size per fortnight.

C. C. LINDSAY & PEIRCE,
180, Hope Street, Glasgow.
(Agents to the Municipal Commissioners of Singapore). D 374

STEPNEY BOROUGH COUNCIL.

ELECTRICITY SUPPLY.

The Electricity Supply Committee of the Stepney Borough Council invite

Tenders from Responsible

Contractors for the CARRYING OUT of the following, viz.:—

(A) The MANUFACTURE, SUPPLY, and ERECTION COMPLETE of COAL HANDLING PLANT, and
(B) The MANUFACTURE SUPPLY and ERECTION COMPLETE of ASH HANDLING PLANT

at the Council's Limehouse Generating Station.

Copies of the general conditions, specification, form of Tender and drawings may be obtained from Mr. WILLIAM C. P. TAPPER, M.I.E.E., Borough Electrical Engineer and Manager, 27, Osborn Street, Whitechapel, London, E.1, upon receipt of a deposit of Five guineas for (A), and of a similar amount for (B). Deposits will be returned to *bona fide* Tenderers after the Tenders have been considered by the Council. Copies of the specifications and drawings may be inspected at the above-mentioned address by appointment.

Tenders on the form supplied, endorsed "Tender for Coal Handling Plant" or "Tender for Ash Handling Plant" as the case may be, accompanied by the specifications, drawings, etc., issued therewith, must be delivered, signed, sealed and addressed to the Chairman of the Electricity Supply Committee, at 27, Osborn Street, Whitechapel, London, E.1, not later than Thursday, May 1st, 1924.

The Council do not bind themselves to accept the lowest or any Tender.

JAMES GEORGE PARKER,
Deputy Town Clerk,

Municipal Offices,
Raine Street,
Old Gravel Lane, E.1.
March 19th, 1924. D 378

CHESTER WATERWORKS COMPANY.

TO PIPE FOUNDERS, ETC.
The Directors invite

Tenders for About 400 Tons

of 12-inch CAST IRON PIPES, as per British Standard Specification.

Particulars, etc., can be obtained on application to the undersigned.

WM. S. MOSS,
Secretary.

Water Offices,
15, Newgate Street, Chester. D 358

METROPOLITAN BOROUGH OF HAMMERSMITH.

ELECTRICITY DEPARTMENT.

TO MAKERS OF COAL DRYING & PULVERISING PLANT.

Tenders are Invited for Coal

DRYING APPARATUS as follows:—

One Coal Dryer, capable of dealing with 10 tons to 15 tons per hour.

One Pulverising Mill capable of dealing with 5 tons per hour.

Detailed information can be obtained from the BOROUGH ELECTRICAL ENGINEER, Electricity Works, 85, Fulham Palace Road, Hammersmith, London, W. 6. D 399

METROPOLITAN WATER BOARD.

DISPOSAL OF WROUGHT IRON BOILERS (OLD AND DISUSED).

The Metropolitan Water Board invite

Tenders for the Purchase and

REMOVAL of FIVE OLD DISUSED CORNISH BOILERS, situated at their Works in Portsmouth Road, Surbiton.

These Boilers may be seen at the above mentioned works at any time between Nine a.m. and Four p.m. on weekdays (Saturdays excepted) on application to the Engineer-in-Charge.

Forms of Tender and Conditions of Contract may be obtained on and after 3rd April, 1924, from the Chief Engineer, Metropolitan Water Board, New River Head, 173, Rosebery Avenue, E.C.1, by personal application (Room 155) or upon forwarding a stamped addressed envelope.

Tenders must be on the official form enclosed in sealed envelopes, addressed to the Clerk of the Board, Metropolitan Water Board, New River Head, 173, Rosebery Avenue, E.C.1, endorsed "Tender for Boilers, Surbiton," and delivered at the Offices of the Board not later than Eleven a.m. on Saturday, 12th April, 1924.

The Board do not bind themselves to accept the highest or any Tender.

G. F. STRINGER,
Clerk of the Board.

Offices of the Board,
New River Head,
173, Rosebery Avenue, E.C.1.
31st March, 1924. D 380

CITY OF NOTTINGHAM.

NORTH WILFORD POWER STATION.

COAL RECEIVING HOPPERS, &c.
CONTRACT No. 8.
TO STRUCTURAL ENGINEERS:—

The Electrical Committee is prepared to receive

Tenders for About:—

136 Tons of IRON AND STEEL WORK, in Stanchions, ordinary and plated beams, Hoppers, dished and flat flooring, staircases, &c.,

required in connection with the above.

Drawings may be seen, and copies of the general Conditions of Contract, Specification, Bill of Quantities, and Form of Tender, etc., may be obtained on and after MONDAY, 7th APRIL, 1924, on application to Mr. T. WALLIS GORDON, City Engineer and Surveyor, Guildhall, Nottingham, on payment of a deposit of Two Pounds, which will be returned on receipt of a *bona fide* Tender,

Sealed Tenders, in the official envelope provided, are to be delivered to the undersigned not later than Nine a.m. on THURSDAY, 17th APRIL, 1924.

The lowest or any Tender will not necessarily be accepted and Tenders will only be accepted from firms who conform to the conditions of the Contract as regards paying the local standard rate of wages, etc., and to the working rules of the Nottingham district.

BY ORDER,
W. J. BOARD,
Town Clerk.

Guildhall, Nottingham.
29th March, 1924. D 366

APPOINTMENTS OPEN.

Technical Writer Wanted for

the Editorial Staff of a leading journal for engineers, etc., must have theoretical and practical experience in the drawing office and workshop and literary ability.—Address stating age, giving record of experience and sending copies of testimonials, D 381, Offices of ENGINEERING.

Ship-repairing.—Wanted,

ASSISTANT MANAGER (Shipbuilder) Mersey District, private Graving Docks. Only applicants having actual repair experience considered. State experience and salary expected.—Address, D 392, Offices of ENGINEERING.

Required, Advertisement

REPRESENTATIVE for a technical newspaper of high standing. Applicants must have had previous experience in calling on shipbuilders and marine engineers and specialty manufacturers. Must be of good address and have unimpeachable references. Good salary and commission.—Address, D 393, Offices of ENGINEERING.

The Royal Air Force

REQUIRES ELECTRICIANS, ELECTRICAL FITTERS, POWER STATION TRADESMEN and WIRELESS OPERATORS. Age limits 19 to 30. Pay from 24/6d. to 34/6d per week, on enlistment, and all found. Allowance for wife and children to men 26 and over.—Write, stating age, or call, INSPECTOR OF RECRUITING, R.A.F., 4, Henrietta Street, Covent Garden, London, W.C.2. D 385

Wanted, An Engineer

Experienced in design, investigation and report work as applied to steam-electric power stations. Duties will require originality in details of design, with particular reference to the turbine room and ability to negotiate contracts for equipment and write a clear comprehensive specification. Location London.—Address, D 372, Offices of ENGINEERING.

BOARD OF TRADE.

STANDARDS DEPARTMENT.

A Vacancy Exists for

an ASSISTANT EXAMINER in the Standards Department of the Board of Trade with establishment in H.M. Civil Service after two years' approved service. The duties are mainly in connection with the control of standards and with the examination of weighing and measuring apparatus of novel types with a view to their approval for use in trade.

Candidates, who must be British subjects by birth and the sons of fathers also British subjects by birth, should possess a University Degree (or its equivalent) in Science or Engineering, and should have had practical workshop experience. Preference will be given to ex-Service men.

The salary is £150, rising by £15 to £300 per annum, with bonus which is re assessed half-yearly on the basis of the average cost-of-living figure for the previous six months. The present bonus on £150 is £94 14 0, making the total remuneration £244 14 0.

Applications with copies of testimonials, should be made in writing to the PRINCIPAL ESTABLISHMENT OFFICER, Board of Trade, Great George Street, Westminster, S.W.1, not later than the 16th April, 1924. D 395

BOMBAY, BARODA & CENTRAL INDIA RLY.

Assistant Carriage and Wagon

SUPERINTENDENT.

REQUIRED for Service in the LOCOMOTIVE, CARRIAGE and WAGON DEPARTMENT of the COMPANY in INDIA.

Candidates should be about 25 years of age, and have had a good general and technical education; preference will be given to one who has passed the Associate Membership Examination of the Institute of Civil Engineers. They must have served an Apprenticeship in the Shops of a British Railway Company or Carriage and Wagon Builder of repute, and have had Drawing Office experience. Knowledge of Carriage and Wagon work is essential; men with only locomotive experience will not be eligible.

SALARY (on appointment).—Rs. 450 per calendar month, or according to age and qualifications, rising according to the Rules in force.

TERMS.—A Three Years' Agreement in the first instance, first-class free passage to India and home again on satisfactory termination of service.

The selected candidate will only be appointed subject to his passing a strict medical examination by the Company's Consulting Physician.

Letters of application, accompanied by a brief record in chronological order of the Applicant's career, with dates, together with copies (NOT ORIGINALS) of testimonials, etc., should be addressed to the undersigned NOT LATER THAN THE 26th APRIL, 1924.

S. G. S. YOUNG, Secretary.

Offices: The White Mansion,
91, Petty France,
Westminster, S.W.1.
2nd April, 1924. D 403

Applications are Invited

for the POST of ENGINEER to take charge of design at H.M.S. "VERNON," Portsmouth.

Salary £300 rising by annual increments of £15 to £500 and full Civil Service bonus.

Present commencing salary including bonus, £446.

The bonus corresponds to a cost of living index figure of 80 per cent. and is subject to increase or decrease by 1/26th for every five points rise or fall in the index figure.

Applicants should have a sound knowledge of electro technics and physics; a sound knowledge and experience in the design and use of electrical apparatus as applied to modern acoustics; and should be capable of supervising initial manufacture and testing of designs.

Experience in Research or Experimental work will be taken into consideration.

Applications should be forwarded to the SECRETARY OF THE ADMIRALTY (C.E. Branch), not later than 19th April. D 399

SOUTH INDIAN RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive written

Applications from Duly

Qualified Candidates for the APPOINTMENT OF TWO ASSISTANT ENGINEERS on the Company's staff in India.

Candidates, who may be between the ages of 23 and 27 years, must have received a sound general and technical education and must have had two years' practical experience of constructional work under a qualified Civil Engineer or as an Assistant Engineer on the Staff of a British Railway Company. Candidates must be Associate Members of the Institution of Civil Engineers, or must have passed one of the qualifying examinations for such membership. Preference will be given to candidates who have had Railway Experience.

The appointment in the first instance will be for three years, and may be extended, in which case the incumbent would be eligible for promotion to the higher grades when vacancies occur.

The starting salary of the successful candidates will be fixed according to their qualifications up to a maximum of Rs. 650 per month, plus Overseas Allowance of Rs. 150 per month.

The incumbent will be entitled to the benefits of the Company's Provident Fund.

The Company will provide a first-class passage to India, and the salary will commence from the date of sailing.

Applicants must give a full chronological record of their career, stating whether they are married or single, and including details of their education, training, and subsequent experience.

Applications must be addressed to the Company's Consulting Engineers, Messrs. FORBES, WHITE AND PARTNERS, 3, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD,
Managing Director.

91, Petty France, S.W.1.
31st March, 1924. D 394

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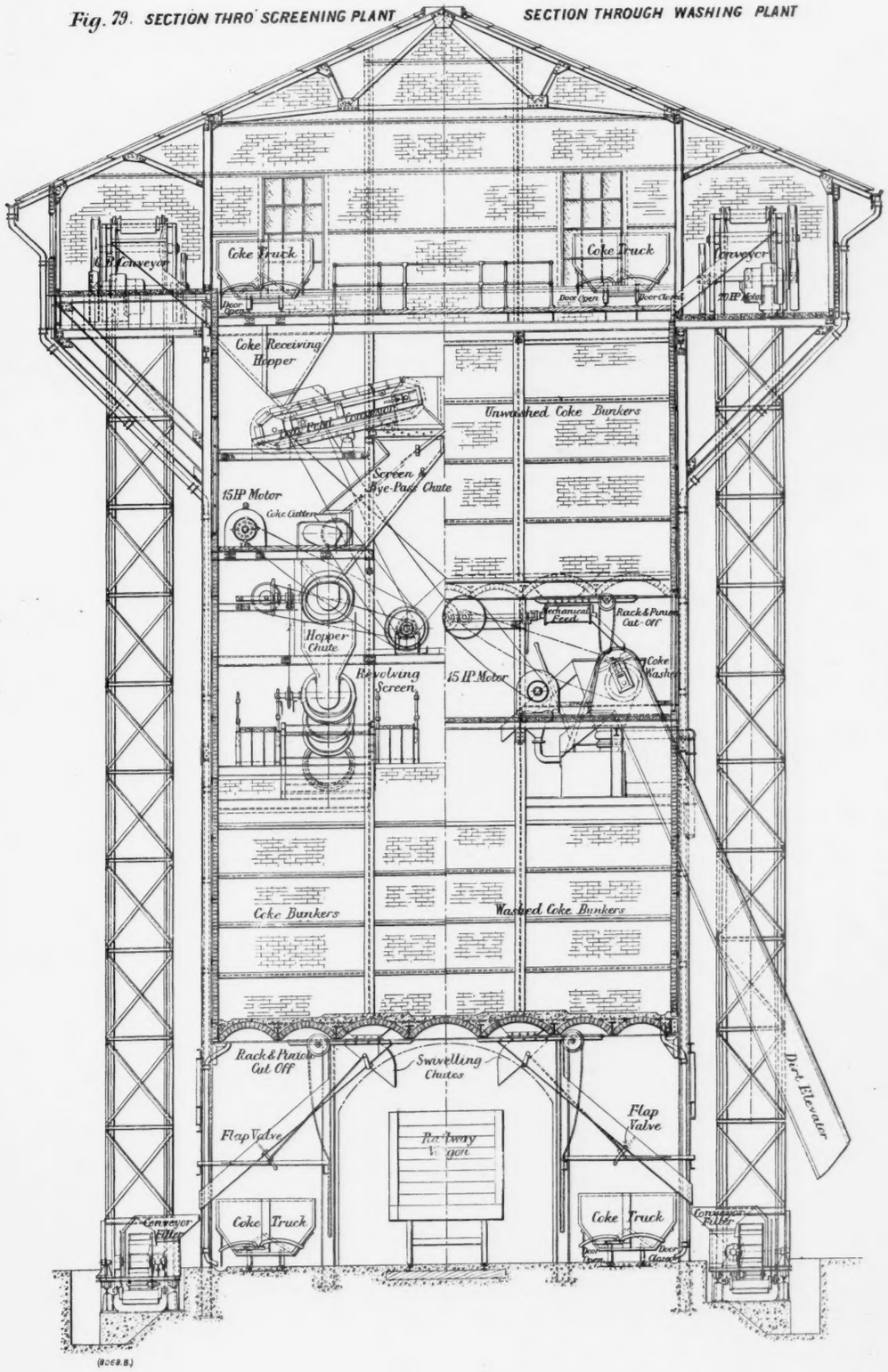
GAS PLANT WITH DEMPSTER-TOOGOOD RETORTS AT SWINDON.

CONSTRUCTED BY MESSRS. R. DEMPSTER AND SONS, LIMITED, ENGINEERS, ELLAND, YORKSHIRE.

(*For Description, see Page* 421.)

Fig. 79. SECTION THRO' SCREENING PLANT SECTION THROUGH WASHING PLANT

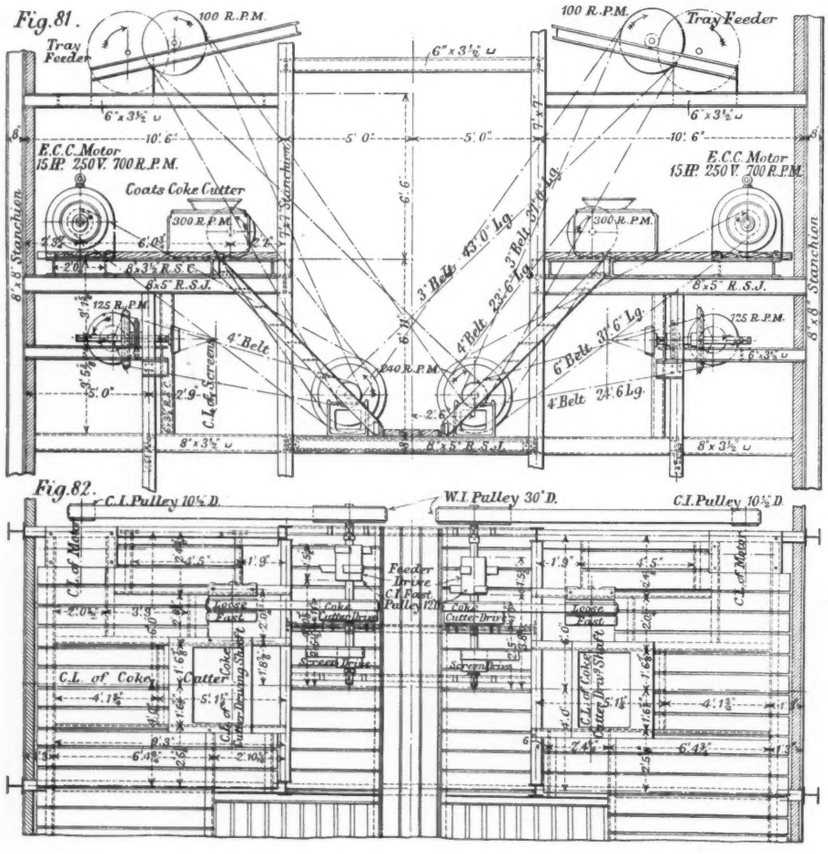


GAS PLANT WITH DEMPSTER-TOOGOOD RETORTS AT SWINDON.

CONSTRUCTED BY MESSRS. R. DEMPSTER AND SONS, LIMITED, ENGINEERS, ELLAND, YORKSHIRE.

(*For Description, see Page* 421.)

FIG. 80. DUPLICATE COKE-SCREENING PLANT.



GAS PLANT WITH DEMPSTER-TOOGOOD RETORTS AT SWINDON.

CONSTRUCTED BY MESSRS. R. DEMPSTER AND SONS, LIMITED, ENGINEERS, ELLAND, YORKSHIRE.

(*For Description, see Page* 421.)

Fig. 85.

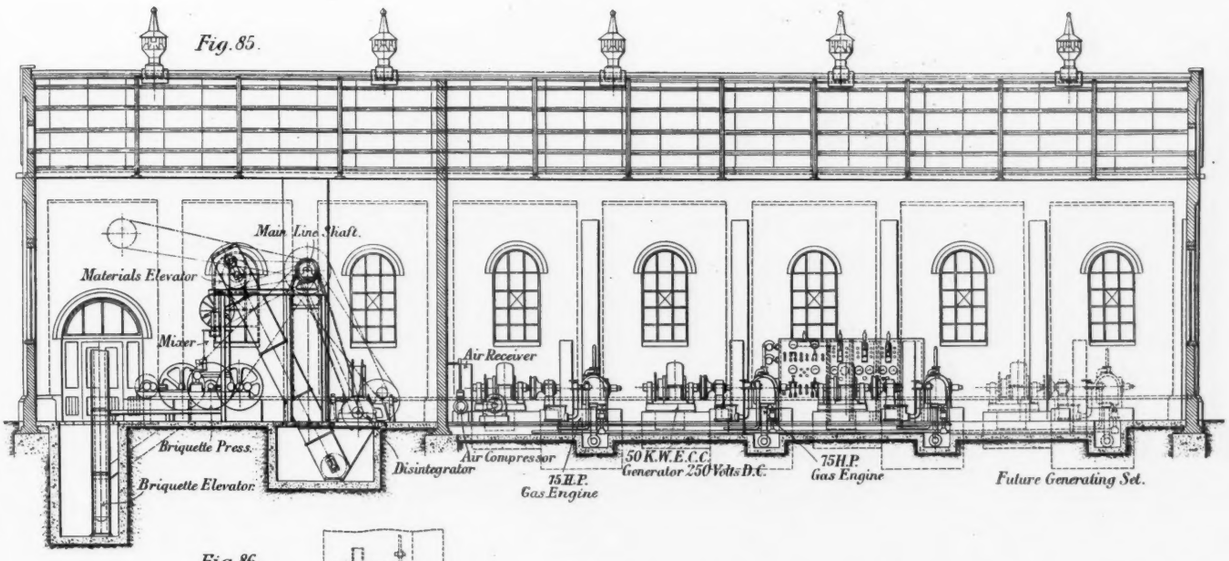
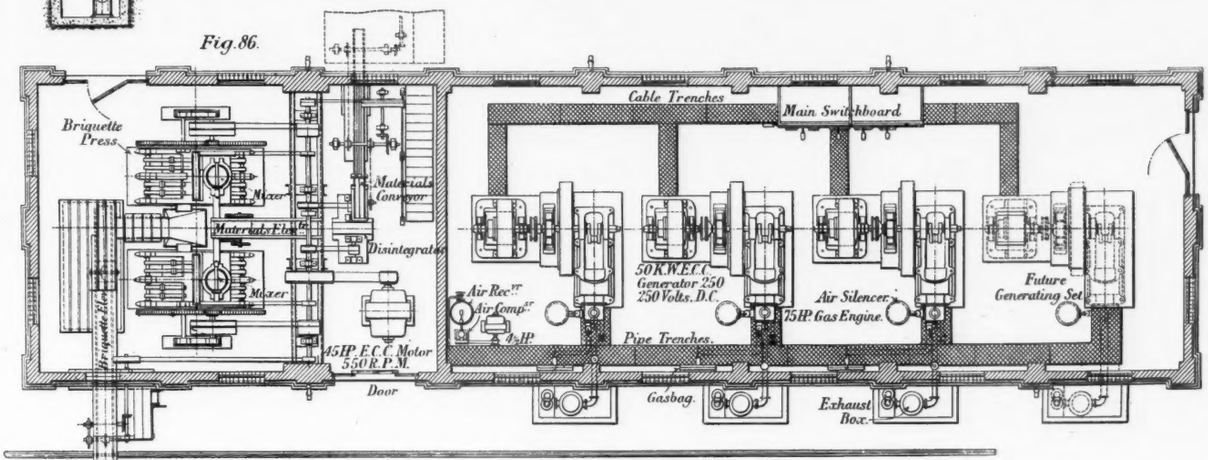


Fig. 86.



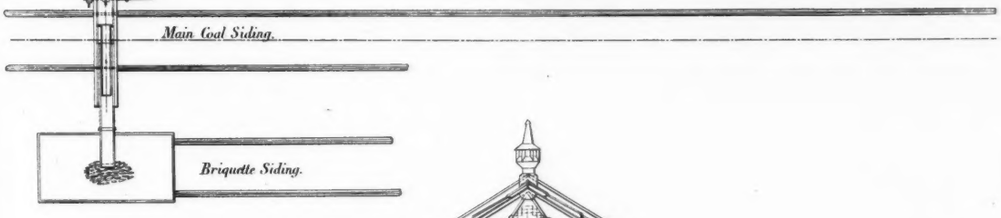
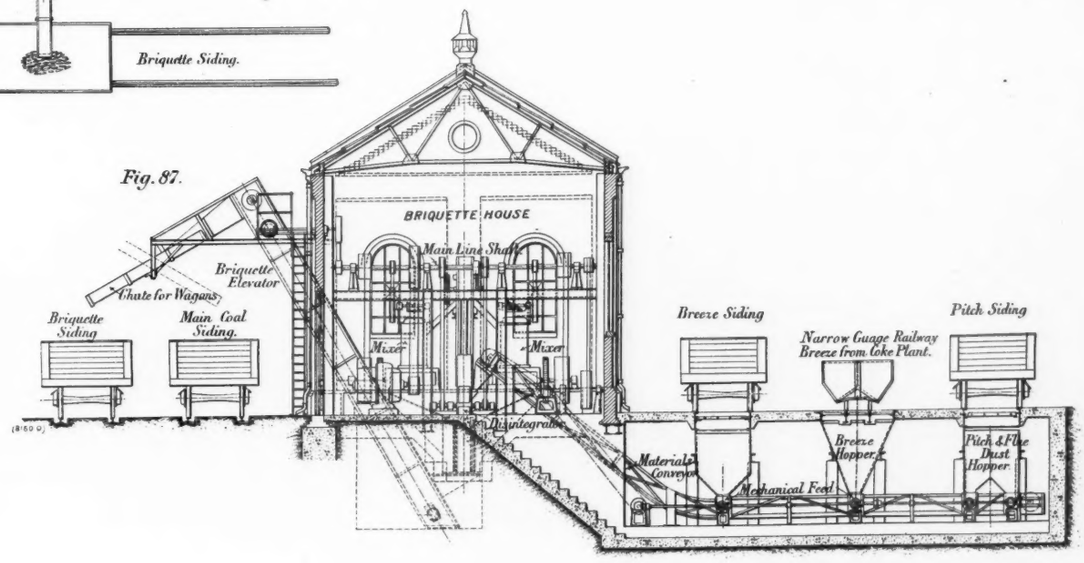


Fig. 87.



GAS PLANT WITH DEMPSTER-TOOGOOD RETORTS AT SWINDON.

CONSTRUCTED BY MESSRS. R. DEMPSTER AND SONS, LIMITED, ENGINEERS, ELLAND, YORKSHIRE.

(*For Description, see Page* 421.)

FIG. 88. VIEW UNDER COKE BUNKERS.

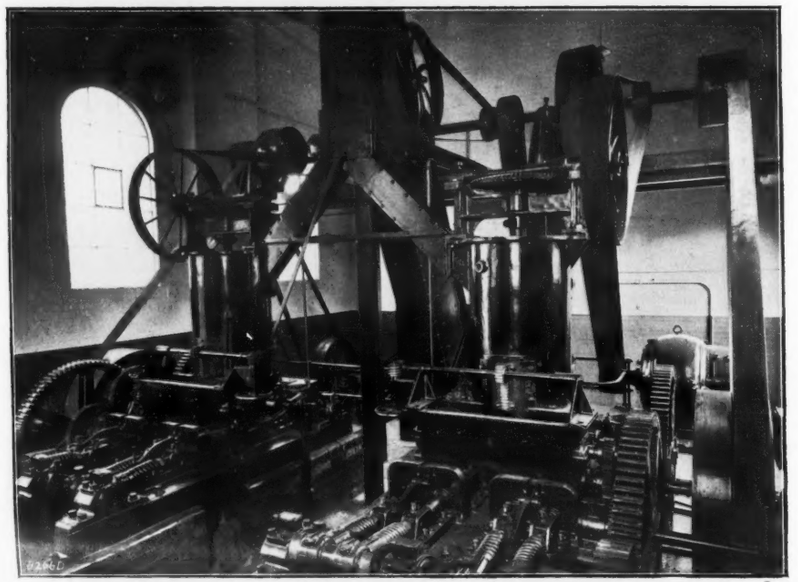


FIG. 89. BRIQUETTING PRESSES FOR COKE BREEZE.

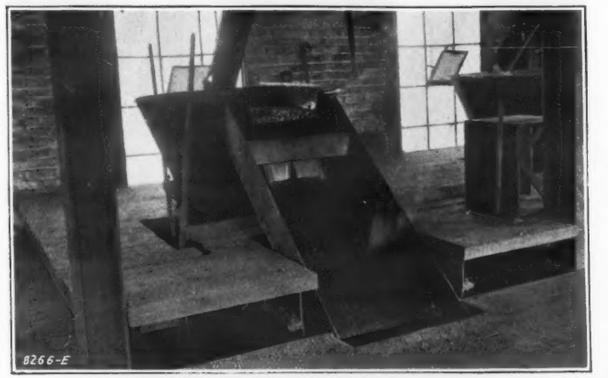


FIG. 90. COKE-WASHING APPARATUS.

FIG. 91. SETTLING TANK OF COKE-WASHING PLANT.

(*To face Page* 421.)

COAL-GAS PLANT AT THE GREAT WESTERN RAILWAY WORKS, SWINDON.

(*Concluded from page* 330.)

In our previous article we described the arrangements for handling the coal and coke, both under normal working conditions and in emergencies arising from the stoppage of the elevators and conveyors. We now propose to deal with the coke screening and washing plant, which is housed in a separate building adjoining the retort-house, as previously mentioned. The building is a steel-framed structure measuring 80 ft. long, 31 ft. wide, and 83 ft. high to the ridge of the roof, the walls being constructed of 4½-in. brickwork with T-bar reinforcement similar to that employed for the retort-house walls, and referred to on page 164 *ante*. The same form and thickness of brickwork are employed for the partitions between the coke-storage bunkers, which extend across the building, forming eight separate compartments.

To follow the general arrangement of the coke plant, reference should again be made to Plate IX, published with our issue of February 8 last, of which Fig. 5 gives a longitudinal section through the building, while a plan is given in Fig. 7 on the same Plate. Fig. 79, on Plate XXVIII, published with this issue, is a transverse section through the building, the left-hand portion being taken through the screening plant, which is situated nearest to the retort-house, while the section given on the right-hand side of the illustration is taken through the washing plant, which is located at the outer end of the building. From Fig. 79 it will be seen that the floors of the bunkers are of jack-arch construction, levelled off with concrete, and the floor, it may be stated, is at a height of 14 ft. 9 in. above the ground level. By means of swivelling chutes, which are shown in Fig. 88, on Plate XXXI, as well as in Fig. 79, coke from any of the bunkers can be delivered into standard-gauge railway trucks running on a track laid along the centre of the building, or into the small ball-bearing wagons used, as previously explained, for handling the coke in emergencies. For moving the standard-gauge wagons, we may mention, an electric capstan is provided near the outer end of the coke-plant building, as shown in Figs. 5 and 7 on Plate IX *ante*, and also in Fig. 88. The chutes are also arranged so that coke can be delivered into the rotary fillers of the gravity-bucket conveyors on either side of the building and carried round by the conveyors to the washing plant or to the retort-house producers, as required.

The bulk of the coke from the retorts is carried round by the conveyors and delivered through chutes and fixed hoppers to the screening plant, which is exactly duplicated on each side of the coke-plant building, although the coke can also be supplied to the hoppers by means of the small wagons and electric hoists referred to in our previous article. One of the hoppers is shown in Fig. 5 on Plate IX *ante*, and also in Fig. 79, on Plate XXVIII, although the former illustration shows the general arrangement of the machinery more clearly. From the receiving hopper, the coke is fed by means of a tray conveyor, best shown in Fig. 79, down a chute and over a bar screen directly into the end of a revolving cylindrical screen. Arrangements are, however, provided so that the coke from either of the two tray conveyors can be by-passed to the set of rotary screens on the opposite side of the plant and thus either set of screens can deal with the whole of the coke received from the retort-house. The object of the stationary-bar screen is to separate the large lumps and pass them through a coke cutter, which reduces them to pieces about ¾ in. in diameter, although the size is capable of adjustment. The broken coke is then delivered, together with the small coke which passes through the stationary screen, into the revolving cylindrical screen, but in the practical operation of the plant the use of the coke-cutter is rarely necessary, the coke being delivered directly into the revolving screen, as previously stated. The perforated portion of this screen has holes 2 in. in diameter, and the coke which passes through the holes is collected by a hopper and delivered into the end of a second revolving screen inclined in the opposite direction to the first. That portion of the coke which is too large to pass through the holes in the first revolving screen falls from the lower open end of the latte into one of two bunkers which serve to store the large coke.

The second revolving screen has two perforated portions with holes ½ in. and 1 in. in diameter, respectively, and it is arranged, as shown in Fig. 5 on Plate IX *ante*, so that the breeze falls through the smaller holes into one bunker, the small coke falls through the larger holes into the next bunker, and the medium-sized coke falls from the open end of the screen into another separate bunker. Thus, of the five bunkers from left to right of Fig. 5, the first two are used for large coke, the third for breeze, the fourth for small coke, and the fifth for medium coke; these bunkers have a total storage capacity of 280 tons. Fig. 80, on Plate XXIX, is a reproduction from a photograph showing the two duplicate sets of breaking and screening plant, while Figs. 81 to 84, on the same Plate, illustrate the driving arrangements. The latter call for no particular comment, except that we may point out that, while each plant is driven by a separate 15-h.p. motor, the drives are interconnected in such a manner that either of the motors can drive either of the plants.

Of the screened coke, the small size is used for rivet-heating in the railway works, while the medium size is employed for the smiths' fires. The smithy coke is all washed before use, and it is for this purpose that the washing plant has been installed. The screened coke to be washed is delivered from the bottom of the low-level bunker in which it is collected into the filler of the gravity-bucket conveyor, carried round by the latter, and delivered directly from the conveyor into two overhead bunkers of brickwork construction, which are together capable of storing 70 tons. These two bunkers are shown on the right of Fig. 5 on Plate IX *ante*, and a half section through one of them is given on the right of Fig. 79, on Plate XXVIII. The washers, four of which are provided (two on each side of the plant), are situated below the overhead bunkers, and are together capable of dealing with 16 tons of coke per hour. As shown in the two illustrations just referred to, and also in Fig. 91, on Plate XXXI, each washer consists of a conical pan into which a continuous flow of water is admitted through an annular opening in the side near the bottom. Coke is supplied from the overhead bunker to the washer pan by means of an automatic feed of the worm type, and any stones, clinker, dust, or dirt present sink through the rising water, the upward velocity of which can be adjusted to suit the particular class of coke being dealt with, to the extreme bottom of the pan from which they are removed periodically through a sliding door. The rising water flows over a lip formed on the upper edge of the pan, carrying with it the comparatively light, clean coke. The lip directs the coke and water on to an inclined screen, clearly shown in Fig. 91, and the washed coke falls down the screen into a bunker at the lower level, while the water which passes through the screen is collected in a tank, which also receives the dirty water from the clinker outlet.

The dirty water runs through a pipe from the collecting tank to a reinforced-concrete settling tank on the ground level, shown in Fig. 90, on Plate XXXI, one of these tanks being provided on each side of the building. The dirt which collects in the bottom of the settling tank is drawn along by a worm conveyor to one end, whence it is raised by a small bucket elevator, shown in both Figs. 79 and 90, and deposited in a separate bunker reserved for the purpose. This material is removed from the bunker at intervals and dumped. The water from which the bulk of the dirt has settled is raised from the settling tank and supplied to the washers by a centrifugal pump, so that it is continuously circulated by this means. The two washed-coke bunkers and the bunker for the dirt have a combined capacity of 100 tons, and these, with the others previously mentioned, give the whole plant a total storage capacity of 450 tons of coke, which is equivalent to three days' production.

Although the method of coke-handling by gravity bucket conveyors adopted at Swindon reduces the production of breeze to a minimum, a certain amount of breeze is, of course, produced, and to transform this into a readily utilisable fuel a briquetting plant, capable of making 3 tons of briquettes per hour, has been installed. We should also mention that it is intended to use the plant for briquetting the cinders recovered from locomotive smoke boxes. The plant is housed at one end of the power-station building, the location of which, relatively to the main buildings of the gas plant, is shown in Fig. 7. on Plate IX *ante*. A longitudinal section and plan of the briquetting plant and power station, drawn to a larger scale, are given in Figs. 85 and 86 on Plate XXX, while a transverse section of the briquetting plant only is reproduced in Fig 87, on the same Plate,

As will be seen from the plan Fig. 7, previously referred to, the standard-gauge track running through the coke plant is continued along on one side of the briquetting plant, as also is one of the narrow-gauge tracks for the small ball-bearing wagons. These tracks serve for the delivery of breeze from the bunker of the coke plant to the briquetting plant, while a third track running from the yard of the railway works is provided for the delivery of pitch, of which about 10 per cent. by weight is required to act as a binding material. From the transverse section of the plant, Fig. 87, on Plate XXX, it will be seen that the tracks run over a concrete floor at the side of the briquetting plant, and through openings in this floor the materials can be dumped from the trucks into hoppers, which direct them on to a slat conveyor. The hopper outlets, it should be explained, are provided with mechanical feeders by means of which the proportions of breeze and pitch can be accurately regulated. At its inner end, the slat conveyor is inclined upwards, and by this means the materials are delivered into a disintegrator, in which the pitch is broken up and intimately mixed with the breeze. From the disintegrator the materials fall into the boot of a short bucket elevator, best shown in Fig. 85, and from the upper end of the elevator the materials fall through inclined chutes, distinguishable in Fig. 87, into the mixers of the two briquetting presses. The latter are illustrated in Fig. 89, on Plate XXXI, and the illustration clearly shows the elevator for the materials and the chutes through which they are delivered into the mixers. The mixers are vertical, cylindrical chambers in which the materials are further mixed by rotating paddles and also heated by steam admitted through small jets at the bottom. From the mixers of each machine the materials pass out through a vertical sliding door, the opening of which can be adjusted by means of rack-and-pinion gear to regulate the delivery, into the trough of a short worm conveyor, by means of which they are fed into the spaces between four pairs of opposing rams worked by cranks and connecting rods. By the action of the rams, the materials are compressed into the form of cylindrical briquettes about 2¾ in. in diameter, 3 in. long, and having slightly rounded ends; each briquette weighs about ½ lb. The briquettes formed in this way fall from both machines into a chute which directs them into the boot of a bucket elevator, and the elevator, the arrangement of which is clearly shown in Figs. 85, 86 and 87, delivers the briquettes into wagons running on standard-gauge tracks on the opposite side of the building to that on which the materials were delivered. The whole plant is driven by a single motor of 45 h.p., and the driving arrangements can be followed from our illustrations without explanation.

The power station, illustrated in Figs. 85 and 86, contains three generating sets, each comprising a 75-h.p. single-cylinder, horizontal gas engine driving, through a flexible coupling, a 50 kw. direct-current, 250-volt generator. Foundations have, however, been provided for a fourth generating set exactly similar to the existing sets, which will be installed when future extensions to the gas plant render it necessary. The plant, it may be mentioned, supplies the whole of the power required for operating the motors in the retort-house and coke plant, as well as for those driving the conveyors, hoists, briquetting plant, &c.

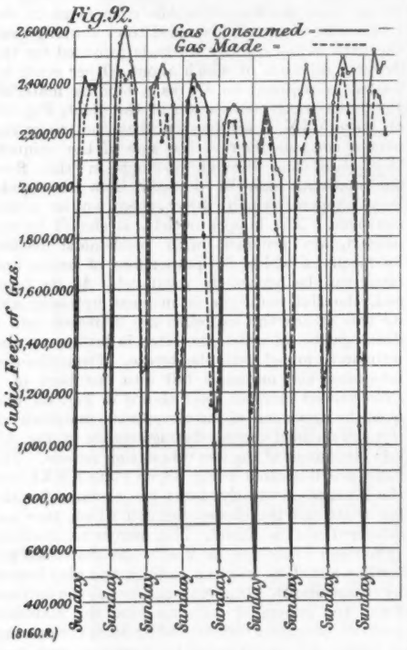
Fig. 91. Settling Tank of Coke-Washing Plant.

Fig. 89. Briquetting Presses for Coke Breeze.

The exhausters, however, are driven by steam engines.

As mentioned in our first article on page 164 *ante*, a new holder with a capacity of 2,500,000 cub. ft. has been ordered from Messrs. Dempster and is now in course of erection. There are several interesting points in connection with the design and construction of this holder, but as it is not yet completed we prefer to defer our description of it to a future occasion. We may, however, conclude our present account of the plant by dealing with the factors which have led to adoption of the new holder. It will be readily understood that when the works close down at midday on Saturday, the demand for gas suddenly decreases to a comparatively small amount, while the full demand is at once restored when the works reopen on Monday morning. The violent fluctuations which occur in the daily demand for gas over a period of eight weeks are well illustrated by the full lines in the diagram reproduced in Fig. 92 annexed. It is, of course, impossible to

Fig.92.



adjust the gas production in exact accordance with the demand but owing to the fact that the storage capacity of the existing holders only amounts to 1,500,000 cub. ft., it is obviously essential greatly to reduce the normal production of 2,500,000 cub. ft. per diem during week-ends. This is at present accomplished by laying off about 25 per cent. of the retorts each week-end, and by slowing down the working of the remaining retorts as far as possible, so that the gas production during the week-end will not be in excess of the storage capacity of the holders; as would be expected, advantage is taken of the week-end period for scurfing any of the retorts. The variation in the gas production effected in this way is indicated by the dotted lines in Fig. 92, but it will be obvious that very careful management of the plant is required in order to supply the works' demand for gas at all times and also to avoid over-production. When the new holder is in use, however, the total storage capacity will amount to 4,000,000 cub. ft., and it will then be possible to work the plant at a fairly uniform rate throughout, the maximum demand of the mid-week period being supplied from the holders, which will be replenished during the week-ends. This should enable a higher degree of efficiency to be attained in the working of the plant, and it will certainly simplify the problem of meeting any sudden demand for gas.

In conclusion, we must express our thanks to Mr. C. B. Collett, M Inst.C.E, the chief mechanical engineer of the Great Western Railway, for permission to publish a full account of the gas plant, and we should also like to congratulate the Company on their enterprise in installing such a complete and up-to-date plant. Our thanks are also due to Mr. H. J. Toogood, of Messrs. Robert Dempster and Sons, Limited, for supplying us with the drawings and photographs illustrating its design and construction, as well as with the greater part of the particulars from which our articles have been prepared. We are also indebted to Mr. H. H. Kinnier, who is in charge of the plant, for his courtesy in providing much of the information given as to its practical working.

THE PRINCIPLE OF DYNAMICAL SIMILARITY, WITH SPECIAL REFERENCE TO MODEL EXPERIMENTS.

By Professor A. H. GIBSON, D.Sc., M.Inst.C.E.

(*Concluded from page* 393.)

17. *Sea-going Qualities of Vessels in a Rough Sea.*—The model method would appear to be specially appropriate for investigating the behaviour of such vessels as self-righting lifeboats, &c., in a heavy sea and when exposed to a strong wind, for although the size of the boats does not preclude full scale experiments being carried out, such tests are dangerous, and it is only on rare occasions that such a combination of wind and sea as tests their qualities to the utmost, is available. On the other hand, to test the same qualities in small scale models, only a very moderate state of wind and wave is necessary, and even if these cannot easily be reproduced by artificial means their natural occurrence is not one of any rarity.

Assuming a model similar in all essentials to the original, having the same form as the original and the same general distribution of weight, so that the radius of gyration about a longitudinal axis through the centre of gravity is in each case proportional to a corresponding linear dimension of the vessel, and a weight which is proportional to the cube of corresponding linear dimensions, the behaviour of the model as regards its angular roll θ will depend upon its length l; the height of the waves h; the force of the wind, which is proportional to v^2; the periodicity of the waves t^{-1} and, since the weight is involved, also on gravity.

The general relationship thus becomes

$$F(v, t, l, h, \theta, g) = 0$$

Taking v, t, and l as our independent quantities, we have, if h and θ are constant

$$K_1 = v^x t^y l^z g$$

$$\therefore \quad l^z t^{-x} l^y l^z l t^{-2} = 0$$

$$\therefore \quad \left.\begin{aligned} x + z + 1 &= 0 \\ -x + y - 2 &= 0 \end{aligned}\right\} \text{ whence } \begin{aligned} x &= y - 2 \\ z &= 1 - y \end{aligned}$$

$$\therefore \quad K_1 = \frac{v^{y-2} l^y \cdot g}{l^{y-1}} = \left(\frac{v\,t}{l}\right)^y \left(\frac{l\,g}{v^2}\right)$$

Similarly

$$K_2 = \left(\frac{v\,t}{l}\right)^y \cdot \frac{h}{l} \cdot$$

and

$$K_3 = \left(\frac{v\,t}{l}\right)^y \cdot \theta.$$

$$\therefore \psi\left[\left(\frac{v\,t}{l}\right)^y \cdot \frac{l\,g}{v^2}\right]\left[\left(\frac{v\,t}{l}\right)^y \cdot \frac{h}{l}\right]\left[\left(\frac{v\,t}{l}\right)^y \theta\right] = 1 \quad (35)$$

For similarity therefore the necessary conditions are

$$h \propto l$$

$$v \propto \sqrt{l}$$

$$t \propto \frac{l}{v} \text{ or } \sqrt{l}$$

in which case θ is the same for boat and model. Thus the behaviour of a model 3 ft. long in waves 2 ft. high, and with a wind of 20 miles per hour, would correspond with that of a boat 27 ft. long in waves 18 ft. high and with a wind of 60 miles per hour.

18. *Suction or Interaction between Passing Vessels.*—When floating vessels are manœuvring in close proximity, forces of interaction are set up which have, in numerous cases, led to disastrous collisions. The behaviour of vessels under such circumstances may readily be investigated by scale models whose weights and moments of inertia are so adjusted as to make them truly similar. This necessitates the weights of the ship and its model being in the ratio of the cubes of corresponding linear dimensions, and their moments of inertia about vertical axes through their centres of gravity being proportional to the fifth powers of these dimensions. In such circumstances the forces involved depend on the displacements and velocities of the vessels and on their distance apart, and the general relationship between these factors; the angle through which the vessels are displaced; and the time before collision will take place if the original distance apart is proportional to the length of the vessels, is given by

$$F(v, t, l, g, \theta) = 0$$

Here, as in the last example, the condition for similarity of behaviour and of path, is

$$\psi\left[\left(\frac{v\,t}{l}\right)^y \frac{l\,g}{v^2}\right]\left[\left(\frac{v\,t}{l}\right)^y \theta\right] = 1 \quad . \quad (36)$$

which is satisfied if

$$v \propto \sqrt{l}$$

$$t \propto \frac{l}{v} \propto \sqrt{l}$$

For a strict comparison of the behaviour of such vessels it is necessary that each be fitted with a propeller, the horse power of the motor driving this being proportional to the cube of corresponding linear dimensions. The depth of water should also be proportional to the dimensions of the vessels.

19. *Resistance of Structures to External Explosions.*—An interesting application of model experiments to investigate the effect of an external explosion on the structure of a ship has been discussed by Mr. E. Buckingham* and by Colonel A. Guidoni.†

The first requirement is that in the initial state, before the explosion, the model system shall, in all essential features, be a scale reproduction of the larger one, the geometrical similarity including the shape and size of the explosive charge and its container, and, for submerged explosions, the depth of submersion. The model structure is to be as nearly as possible geometrically similar to the original as regards the parts affected by the explosion. With built-up structures it is not practicable to make a model accurately to represent its prototype, but since strength is more important than mass, the main point in designing the model is to ensure that the strength of corresponding parts shall be reduced in the correct ratio rather than to have all their dimensions reduced in the same ratio as corresponding lengths.

With such a model the deformation depends upon the tensile strength s, and density ρ of the structural material; the mass M of and the time t to complete the burning of the explosive; the density σ and elasticity K of the medium (water). Except in the case of a deeply immersed body, the effect of hydrostatic pressure may be neglected, in which case gravity does not affect the results.

In this case the fundamental relationship becomes

$$F(l, s, \sigma, M, t, \rho, K) = 0$$

from which, in the usual way, taking l, σ, t as the independent variables we get

$$K_1 = \left[\frac{M}{l^3 \sigma}\right] \qquad K_2 = \left[\frac{l^2 s}{l^2 \sigma}\right]$$

$$K_3 = \left[\frac{\rho}{\sigma}\right] \qquad K_4 = \left[\frac{s}{K}\right]$$

or

$$\left(\frac{M}{l^3 \sigma}, \frac{l^2 s}{l^2 \sigma}, \frac{\rho}{\sigma}, \frac{s}{K}\right) = 1 \quad . \quad . \quad (37)$$

Whatever the form of the function ψ we know that the deformations which it describes must be similar to those of the original if each of the terms $\frac{M}{l^3 \sigma}$ &c., is kept constant.

If the same explosive is used throughout and if a material having the same density and tensile strength and shear strength is used for both model and original ρ/σ and s/E will be constant, and it only remains to ensure that M/l^3 and t/l shall also be constant.

The first condition is satisfied if the closeness of packing of the explosive is the same in both cases. The condition for the constancy of the term t/l is dealt with in detail in Mr. Buckingham's paper. Briefly it is concluded that the detonator used for

* Journal American Society of Naval Engineers, vol. xxxiii, No. 2, May, 1921, page 227.

† *Rivista Marittima*, 1910; also Journal Am. Soc. N.E. May, 1920.

firing the model charge must be of such strength as to make the speed of the detonation wave constant from the start, a point which can be determined from experiments on extended trains of the same explosive.

In the case of experiments on submarines in which hydrostatic pressure is an essential element, this is to be taken into account by introducing the hydrostatic pressure p into equation 37. This introduces another term $K_5 = \left[\frac{p}{s}\right]$ which, for constancy, indicates that the experiments should be carried out not at depths proportional to l, but at equal depths.

20. *Critical Speed of Shafts.*—The frequency of lateral vibration of a shaft may evidently depend upon its length and diameter, its density and the modulus of elasticity of its material, so that

$$F(n, l, d, \rho, E) = 0$$

Taking n, l, and ρ as independent quantities makes

$$K_1 = \left[\frac{E}{n^2 l^2 \rho}\right] \qquad K_2 = \left[\frac{l}{d}\right]$$

Thus in similar shafts of the same material

$$n \propto 1/l$$

It is worthy of note that this applies either to an unloaded or a loaded shaft, since in the latter case the loads, if of the same material, and to the same scale, are simply functions of the length and diameter.

The foregoing results are in accordance with the usual formulæ,

$$n \propto \frac{1}{l^2}\sqrt{\frac{E\,d^2}{w}}$$

for an unloaded shaft, where w is the weight per unit volume,

$$n \propto \sqrt{\frac{E\,I}{W\,l^3}}$$

for a shaft carrying a load W where $I = \frac{\pi r^4}{4}$,

and

$$n \propto \sqrt{\frac{E\,I}{W\,l^3\left(1 + c\,\frac{k^2}{l^2}\right)}}$$

for a shaft carrying a load W whose dimensions are large. Here k is the radius of gyration of the weight about a diameter, and c is a numerical constant.

In these cases if the shaft and model are similar,

$$W \propto wl^3; \quad I \propto d^4 \propto l^4;$$

while k^2/l^2 is dimensionless, so that

$$n \propto \sqrt{\frac{E\,d^2}{wl^4}} \propto \frac{1}{l}\sqrt{\frac{E}{w}}$$

21. *Secondary Effect due to Gravity.*—The foregoing results apply strictly only to a vertical shaft, or to a horizontal shaft of such stiffness that the deflection due to the weight is negligible. If this factor become appreciable it is necessary to introduce the factor g into the original relationship, and this involves another term

$$K_3 = \frac{g}{n^2 l}.$$

Since this necessitates n being proportional to $1/\sqrt{l}$ it evidently prevents exact similarity between a model and its original, and since the deflection due to weight is relatively greater in a model, will tend to reduce the critical speed of a model as compared with that of the original.

22. *Torsional Vibration of Shafts.*—Here the general relationship is identical with that for lateral vibrations except that C, the shear modulus of the material, takes the place of E, and, as before, in similar shafts similarly loaded

$$n \propto 1/l$$

From general considerations it may be shown that, for an unloaded shaft of uniform diameter, the frequency of the fundamental natural vibration is

$$n = \frac{1}{4l}\sqrt{\frac{C\,g}{w}}$$

where w is the weight per unit volume.

In this case the frequency is independent of the diameter.

If the shaft carries a single load at the free end, the mass moment of inertia $I\left(= \frac{W}{g}k^2\right)$ of which is so large that that of the shaft is negligible, we have

$$n = \frac{1}{2\pi}\sqrt{\frac{C\,J}{I\,l}} = \frac{1}{2\pi}\sqrt{\frac{C\,J\,g}{W\,k^2\,l}} \propto \sqrt{\frac{C\,d^4\,g}{W\,k^2\,l}}$$

so that

$$\frac{n_m}{n} = \sqrt{\frac{d_m^4\,W\,k^2\,l}{d^4\,W_m\,k_m^2\,l_m}}$$

if C is the same for both. If the model and the original are of the same material

$$\frac{W_m}{W} = \frac{l_m^3}{l_m^3}; \quad \frac{d_m}{d} = \frac{l_m}{l}$$

$$\frac{k_m}{k} = \frac{l_m^2}{l^2}$$

$$\therefore \frac{n_m}{n} = \sqrt{\frac{l^2}{l_m^2}} = \frac{l}{l_m}$$

so that n is inversely proportional to l.

It follows that by making the model similar in every respect to the original, the frequency of vibration due to the applied weight and to the inertia of the shaft are each inversely proportional to l, and the resultant frequency will therefore be inversely proportional to l.

The same applies if the shaft is of varying diameter and carries a number of weights.

In the case of a shaft carrying a complicated system of loads it is impossible to calculate the torsional vibrations with any degree of accuracy, and model experiments would often be extremely valuable. In many cases, however, the natural frequency of such an original is high, and that of a small scale model would usually be inconveniently high.

This drawback may be obviated by reducing the diameter of the model in a greater ratio than the length.

Since n is proportional to $\sqrt{\frac{d^4}{W\,k^2 l}}$, it follows that any change in the ratio of corresponding diameters unaccompanied by a change in the lengths has no effect on n, since W is now proportional to ld^3, so that n is still inversely proportional to l. For accurate results it is, however, necessary, as for lateral vibrations, that the shaft be so proportioned or so mounted vertically that its weight, as opposed to its inertia, has no appreciable effect.

EFFICIENT CASTING DESIGN.

By F. C. EDWARDS.

ALTHOUGH the ultimate purpose of a casting is, strictly speaking, the primary consideration in its design, it should not be the only consideration. Efficiency, here, as elsewhere, connotes the best use of labour and material in production. And the quality of castings, no less than their cost of production, is almost invariably affected by the methods by which they are produced. These methods are largely determined by design.

Really efficient casting design is extremely rare. In the simplest, as well as in the most complicated of castings, one may find hindrances to production and more or less wastage—or misuse—of material. The reason is not far to seek. Broadly speaking, the cause is two-fold. In the first place, the drawing office seldom appreciates the enormous effect of good and bad design, respectively, upon quality and quantity of output. It thus unconsciously imposes an initial handicap on foundry efficiency. Secondly, the foundry is usually too prone to accept, and to make the best of, any design it may be called upon to execute. Such acquiescence tends to perpetuate bad design.

The special peculiarity of casting design lies, of course, in the fact that metallurgical considerations must supplement mathematics in arriving at the strength of a component. However accurately the loads which the component is required to carry are calculated and allowed for, and however great the "safety factor" employed, unless the effects, say, of shrinkage, are taken into account, the casting may fail in service. In extreme cases of bad design, the casting literally falls to pieces under its own cooling stresses.

It seems desirable, therefore, that the draughtsman who is accustomed to designing structures, say, of wood or of mild steel, in order efficiently to design castings, should "adopt a new way of thinking." That this is a vital preliminary is shown by a moment's consideration of the evolution of design in general. It is invariably found that, in the employment of a new material, the old designs—*i.e.*, those used with the earlier (and, perhaps, fundamentally different) material—persist and prejudicially retard the establishment of the new material. The best known case, perhaps, in which existing design was "carried forward" into a new set of conditions is that of the motor-car. The designers of the earlier forms blindly followed the shapes of the horse-drawn vehicles. Redundant features (*i.e.*, viewed in the light of present-day motor-car evolution) were allowed to remain, and improvements in design, rendered possible by the new method of propulsion, were generally ignored.

Similarly with casting design. It is by no means uncommon to find castings designed in a manner which would be quite satisfactory if they were to be composed, say, of wood. Adjoining members have sharp re-entrant angles, which remind one of framed woodwork. And comparatively light sections of metal in close contiguity with heavy sections resemble thin, panelling attached to strong beams. These incongruities (*i.e.*, from the point of view of casting design) are even met with in combination. Such cases may be said to be the foundryman's *bêtes noires*: try as he may, he cannot ensure a sound casting in these circumstances. On the other hand, only a limited use is made of the vast potentialities of casting metal into moulds. Forms, which, in materials where grain direction has to be considered, would be far too fragile for purposes of utility, may be produced *ad infinitum*. Indeed, the curved shapes—S-shaped arms, for example—by tending to neutralise cooling stresses, actually promote the strength of a casting.

To be really efficient, casting design should tend to reduce the operation of moulding to its simplest possible terms—consistent, of course, with the ultimate purpose of the casting. This naturally involves some knowledge of foundry practice on the part of the draughtsman. Having decided, from the general contour of the job, which way the pattern will best withdraw from the mould, the draughtsman should arrange the details of the design so as to facilitate such withdrawal. A good taper, for instance, judiciously applied (*i.e.*, wherever the nature of the design renders permissible) will do much in the way of securing accuracy by obviating disturbances of the mould during the withdrawal of the pattern. And, of course, it facilitates speedier production. The necessity for loose pieces in moulding should be reduced to a minimum. Many a casting has been rejected as scrap because of some loose piece on the pattern being moved out of position whilst the job was being moulded. Sometimes, indeed, the loose piece is inadvertently left in the mould, and, if it happens to be of wood, it is subsequently destroyed by the molten metal.

In repetition work, especially, it pays to differentiate between good and bad casting design. The cumulative effect of eliminating even minor hindrances to production, or of the saving of a small amount of metal on each casting, may, on a large order, easily make the difference between profit and loss.

That design *per se* is the ultimate determining factor of the strength of a casting is seen from testing considerations. It is generally admitted that, as a criterion of the strength of a casting, the test bar test may be worse than useless—it may give a false sense of security. Actually, as a measure of strength (*i.e.*, strength of casting as a whole), its worth — even if it is cast on the casting—is strictly limited to itself: it indicates the composition of the metal at its own peculiar section when located in the particular part of the mould and subjected to the specific temperature conditions in which it was itself cast and cooled. The same metal, given a different cross section, or cast and cooled under different conditions gives different test results. Hence the vital importance of arranging casting design so as to obtain, from the metal employed, and under ordinary foundry conditions, the maximum strength of which it is capable of developing. This, with judicious simplification of moulding operations, may be said to constitute efficient casting design.

BRITISH EMPIRE EXHIBITION POWER STATION: 1,500-KW. TURBINE.

CONSTRUCTED BY MESSRS. JAMES HOWDEN AND CO., LIMITED, ENGINEERS, GLASGOW.

(*For Description, see opposite Page.*)

Fig.43.

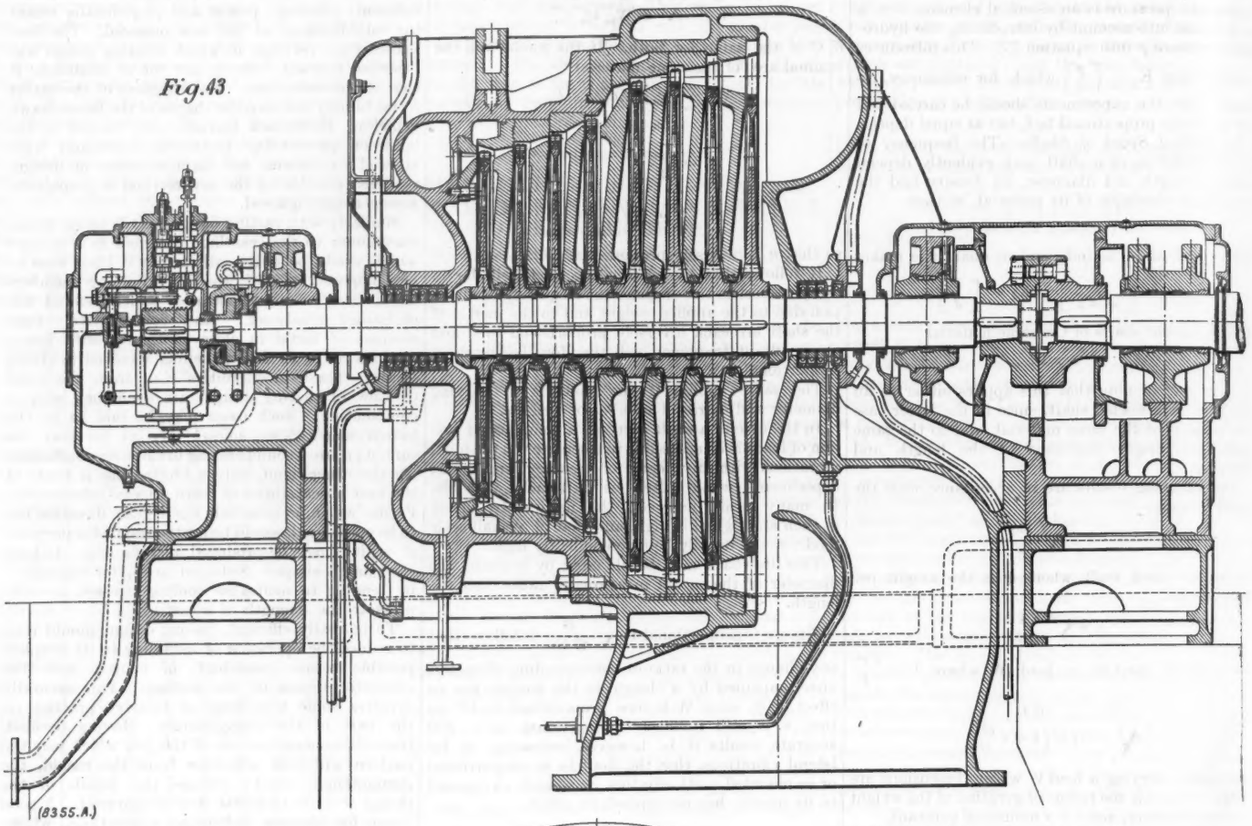
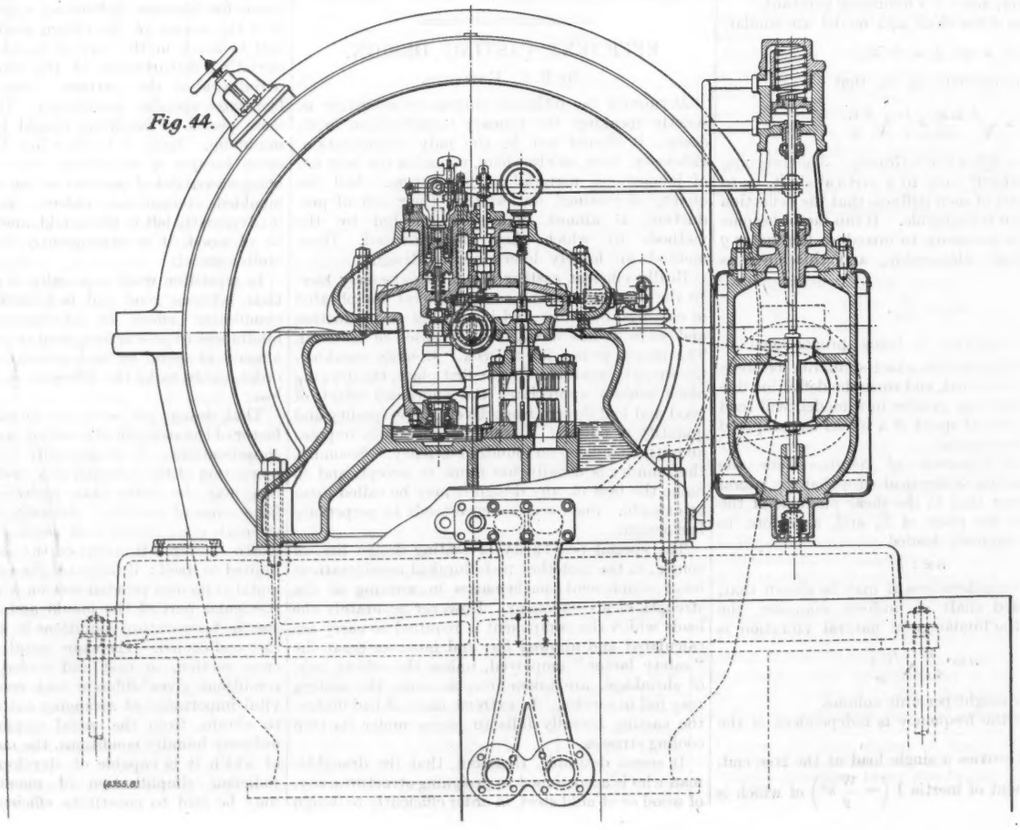


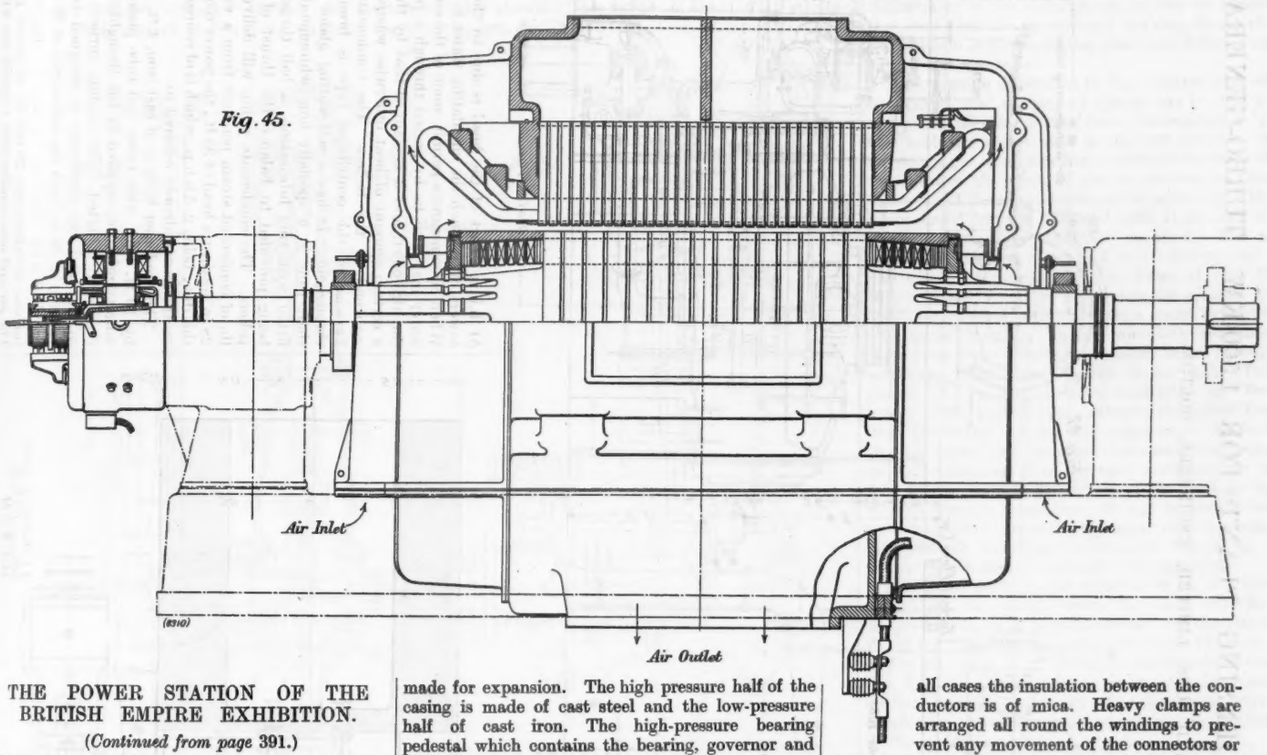
Fig.44.



BRITISH EMPIRE EXHIBITION POWER STATION; 1,500-KW. ALTERNATOR.

CONSTRUCTED BY THE GENERAL ELECTRIC COMPANY LIMITED, ENGINEERS, BIRMINGHAM.

Fig. 45.



THE POWER STATION OF THE BRITISH EMPIRE EXHIBITION.

(*Continued from page* 391.)

In our last article we illustrated and described the turbo-generator of the British Thomson-Houston Company, with Cole, Marchent and Morley's condensing plant, which is situated at the boiler-house end of the engine room. The set next to it is of similar size and capacity, namely 1,500 kw. at 3,000 r.p.m., but represents the productions of three other firms, in so far as its main component parts are concerned. The turbine, of which sectional drawings are given, in Figs. 43 and 44 on the opposite page has been constructed by Messrs. James Howden and Co., Limited, of Glasgow. It drives a 3,300 volt 50 cycle 3-phase alternator by the General Electric Company, Limited, of Witton, Birmingham, and exhausts into a condensing plant by Messrs. John Musgrave and Sons, Limited, of Bolton. The steam turbine, which is designed to use steam at 200 lb. per square inch with 212 deg. of superheat, and to exhaust at 28 in. vacuum, is of the straight impulse type with eight stages, each comprising a single impulse wheel. The wheels are keyed to the shaft and are located axially by means of carrier rings, similar to piston rings which are sprung into position. The whole series of wheels is held by nuts at the ends, as shown.

The rim of each wheel is provided with a T-shaped slot to receive the blades and distance pieces, which are introduced at a "gateway" which is subsequently closed by a special filling piece, the latter also serving to lock the blades in position. In the last two stages where the blade speed is higher and the stresses consequently greater, each blade is combined with its own distance piece, the whole being milled out of solid material. The longer blades are also tapered in thickness from root to tip. The glands where the shaft passes through the casing, are fitted with carbon rings made in segments and held round the shaft by garter springs. A cast-iron lantern ring is fitted on each gland, and through this ring steam at slightly above atmospheric pressure is admitted, thus effectually preventing the inward leakage of air which otherwise would spoil the vacuum.

The turbine casing is secured to, and supported by, the bearing pedestals. The casing and shaft are thus registered in alignment, and provision is made for expansion. The high pressure half of the casing is made of cast steel and the low-pressure half of cast iron. The high-pressure bearing pedestal which contains the bearing, governor and oil pump, as shown in Figs. 43 and 44, is free to move axially. The oil pump is of the rotary valveless type, and is driven directly from the turbine shaft by worm gearing. This pump supplies low-pressure oil to the bearings and high-pressure oil to the governing system. The latter consists of a light sensitive centrifugal governor working in conjunction with a hydraulic differential piston relay valve, servo-motor and throttle-valve. It controls the speed of the turbine to within 0·2 per cent. under normal conditions. The emergency governor is of the centrifugal type, mounted on the extreme end of the turbine shaft, and closes the main throttle valve by means of a relay valve. An overload valve is provided at the H.P. end of the casing and is operated by hand. Speed adjustment is arranged for either by hand or by electrical control from the switchboard. The thrust-block is of the Michell type, and is carried by the H.P. bearing bush. A solid forged-steel coupling connects the shaft of the turbine with that of the alternator.

The alternator, constructed by the General Electric Company, Limited, at their Witton Works, is illustrated in part section in Fig. 45, above. It is a 1,500 kw. 3,000 rev. machine, producing 3-phase 50 cycle current at 3,300 volts between phases. The machine is of the enclosed type with drum-type rotor and forced ventilation. The stator frame is a heavy casting of box section bored to accommodate the laminations, which are clamped between stout end plates in such a way that they are not traversed by any bolts. All longitudinal ribs in the casing are fitted with dovetailed keys to which the stampings are secured. These are re-annealed after punching and no filing or scraping of their edges takes place after they are assembled, in order to avoid the increased eddy current losses which have been traced to this practice. The insulating tubes of the stator conductors are of micanite, and are moulded on to the coils. Each coil with its insulator is pushed through the slot from one end, the end of the coil being left straight for this to be done. Each conductor is then bent up singly, thus making it absolutely certain that the insulation of the slot and also that between adjacent conductors is in perfect condition. In all cases the insulation between the conductors is of mica. Heavy clamps are arranged all round the windings to prevent any movement of the connectors or of the projecting ends of the coils under the stresses imposed in case of a short circuit or other disturbance of the electrical system. The stator windings of all the company's machines are tested to twice the working voltage plus 1000 volts between the finished coils and between any coil and earth after completion, and the rotor winding is required to withstand 25,000 volts to earth.

As will be seen by Fig. 45, fans are arranged at both ends of the rotor to draw air through channels in the end shields, and to force it into the space enclosed by the guards of the stator winding. After cooling the ends of the stator coils, the air passes through ducts in the stator core into the delivery air belt round the machine. The cooling of the rotor is effected by the fan action of the rotor itself, air being drawn in at the ends and passing along axial ducts underneath the rotor coils. It escapes from these ducts by radial vent spaces into the air gap, and leaves the machine by way of special ducts through the stator laminations. The rotor body and shaft are in one solid forging with slots milled axially all round the periphery to take the rotor windings. The rotor coils are completely shaped before they are put into position in the slots, and the latter are then closed by metal wedges. The ends of the windings are covered by steel shrouds lightly shrunk on. The shrouds are located at one end by a spigot turned on the rotor, and at the other by steel discs, mounted on the shaft. Balancing grooves are provided at both ends of the rotor, and the windings are completely boxed in and protected from injury.

The exciter, which is fitted with commutating poles, is carried from the outboard bearing. The exciting current is brought to the rotor winding by means of steel slip rings shrunk on iron sleeves and insulated therefrom by moulded-on mica bushes. The leads connecting the rings to the rotor windings are sunk in grooves in the shaft and protected by key-shaped covers.

The general arrangement of the condensing plant for the turbine and alternator which we have just described is illustrated in Figs. 46 to 48 on page 426. This condenser and its auxiliaries have been supplied by Messrs. John Musgrave and Sons, Limited, of

BRITISH EMPIRE EXHIBITION POWER STATION; CONDENSING PLANT FOR 1,500-KW. TURBO-GENERATOR.

CONSTRUCTED BY MESSRS. JOHN MUSGRAVE AND SONS, LIMITED, ENGINEERS, BOLTON.

Fig. 46.

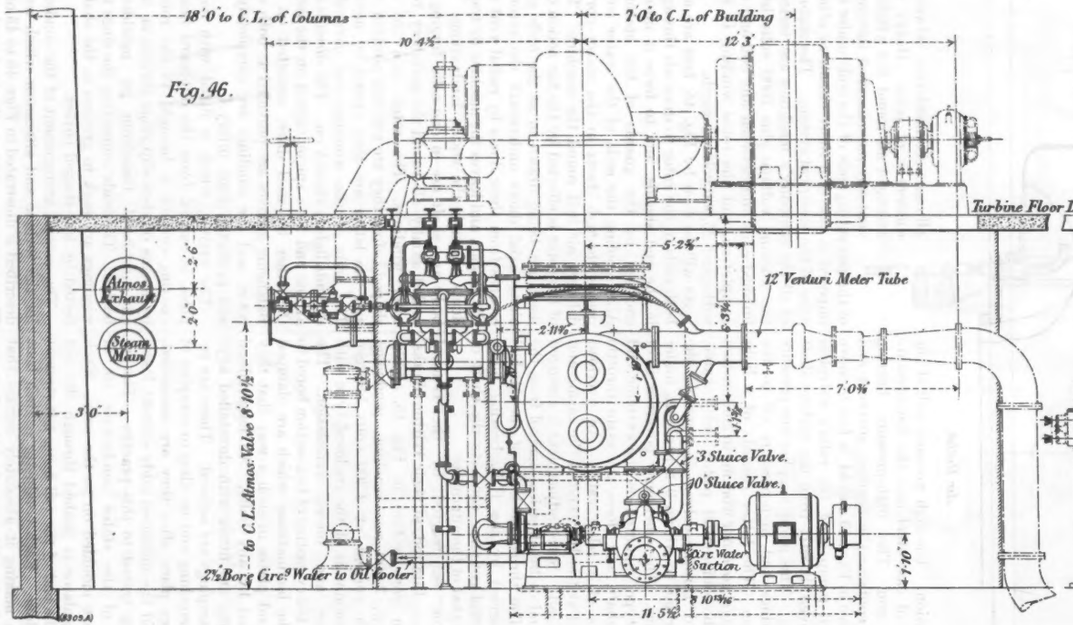
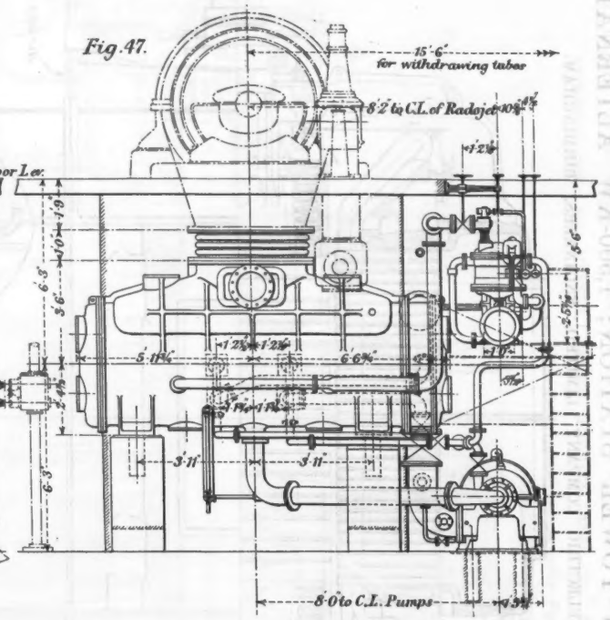


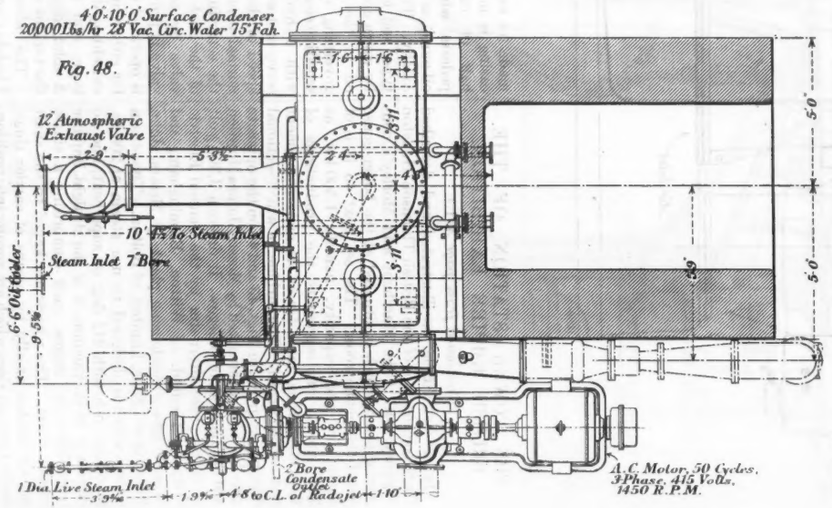
Fig. 47.



Bolton. The condenser, as will be seen, is placed crosswise underneath the turbine to which it is connected by a corrugated copper expansion piece. The air-extraction apparatus is arranged just below the turbine floor level from which the ejector nozzles can be controlled, while the circulating pump and condensate pump are set in line on a common bedplate alongside the turbine foundations and driven directly by an electric motor. Everything is accessible and in full view of an operator on the turbine floor. The circulating pump, constructed by Messrs. Mather and Platt, Limited, is of their "Lonovane" type, bronze fitted throughout. The pumps and motor are all connected by means of flexible couplings. The motor, which is of the 3-phase 415 volt slip-ring enclosed type, developing 61 b.h.p. at 1,450 r.p.m. was constructed together with its liquid starter, by the General Electric Company, Limited.

The circulating pump, in addition to providing cooling water for the condenser, also supplies cooling water to the lubricating oil cooler for the turbine and to the "Premier" air cooler underneath the generator. The pump is designed for a capacity of 2,350 gallons of water per minute, delivered against a total head of 50 ft., the power required being

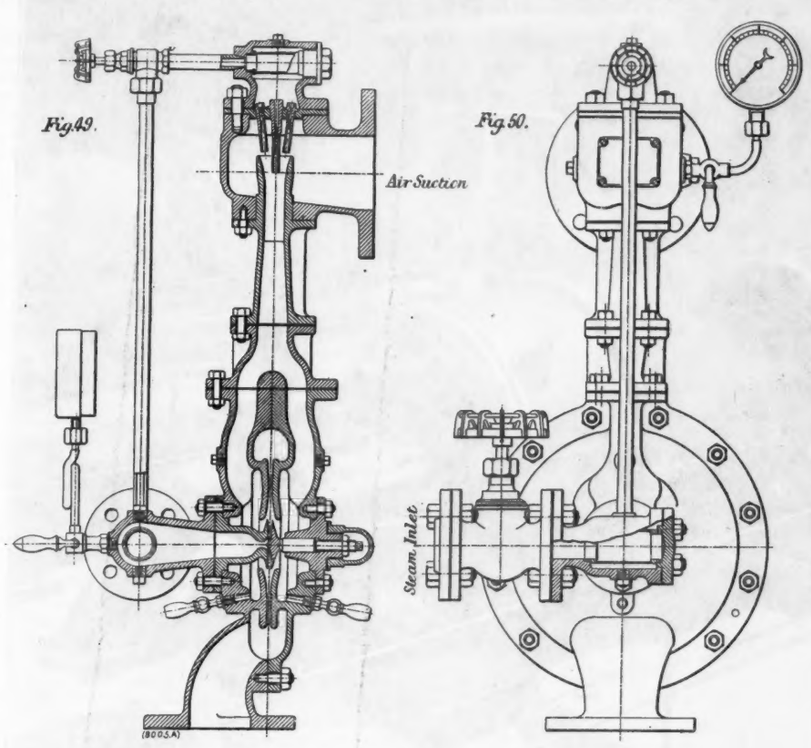
Fig. 48.



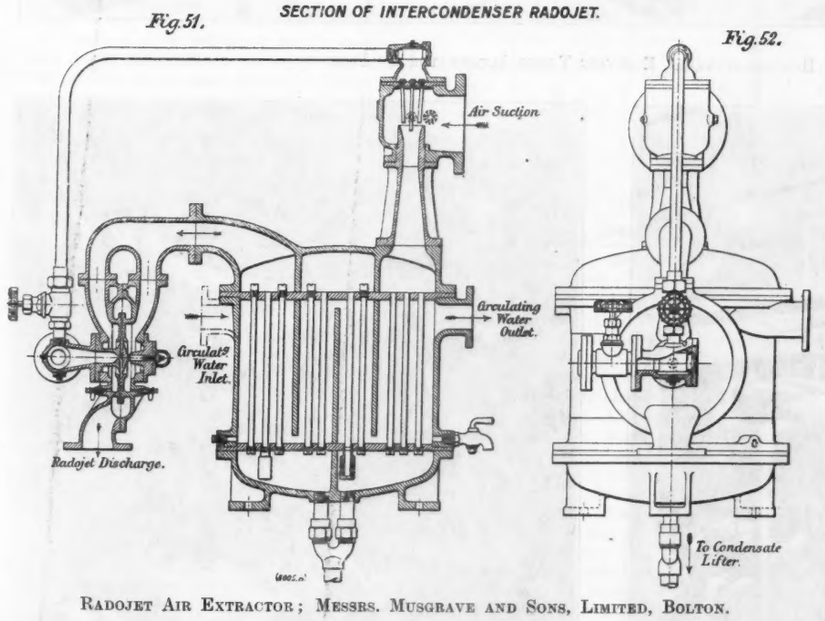
51 b.h.p. Part of the head is due to the cooling towers over which the circulating water is pumped. When circumstances permit, some of the condensate water may also be by-passed through a portion of the air cooler, and it is claimed that by this means a certain amount of heat otherwise wasted can be returned to the boilers. The condensate pump, likewise of the centrifugal type is bronze fitted throughout. It has a self-seating gland and the shaft runs in a specially long whitemetal bearing fitted with ring lubrication, a ball thrust washer being provided to balance the thrust of the impellers. The condensate pump will deliver 20,000 lb. of condensed steam per hour from a vacuum of 28 in. against a head of 35 ft., the power required for this duty being 2·5 b.h.p., which is of course supplied by the motor already referred to.

The condenser body is of cast iron, 4 ft. diameter by 10 ft. long, with tubes and tube plates of Admiralty mixture, supplied by the Broughton Copper Company, Limited. The cooling surface is 2,735 sq. ft., and the condenser is designed to give a vacuum of 28 in. with the barometer at 30 in. when supplied with water at 75 deg. F., and when the turbine is exhausting 20,000 lb. of steam per hour. The air and non-condensable vapours are withdrawn

from a devapourising chamber at one side of the condenser after having been cooled by tubes in this chamber through which part of the circulating water passes. The apparatus by which they are withdrawn, and the vacuum maintained is Messrs. Musgrave's Radojet extractor of the inter-condenser type. This consists of two steam ejectors in series, is in communication with the condenser, and the live steam enters through the stop valve and strainer, shown in Fig. 50. Part of the steam is led to the first ejector by a small external pipe, the supply being independently controlled by the single valve shown. This supply is shut off at starting, the first ejector not being brought into action until



SECTION OF INTERCONDENSER RADOJET.



RADOJET AIR EXTRACTOR; MESSRS. MUSGRAVE AND SONS, LIMITED, BOLTON.

with a surface condenser between them. For certain purposes the Radojet is made without the intermediate condenser, and the design is then as shown in Figs. 49 and 50 on this page, which we reproduce, as they show the essential features of the ejectors very clearly. The typical characteristic of the apparatus is the radial flow ejector used to effect the final delivery of the air.

The air suction branch shown in the illustration, the second ejector has created a vacuum of about 25 in. The first ejector consists of a number of expanding nozzles discharging into a throat-pipe and entraining the air from the condenser. The mixture of air and steam leaves this ejector at a pressure several inches above that in the condenser. The live steam operating the second ejector issues radially from its nozzle in the form of a flat sheet. The relatively large surface of this sheet entrains the mixture and compresses it to atmospheric pressure in the annular diffuser. The whole then passes into the discharge belt around the diffuser and escapes at atmospheric pressure through the discharge branch at the bottom of the apparatus. Adjustment of the radial steam jet can be effected if desired while the apparatus is working, by altering the position of the deflecting plate which forms one side of the nozzle.

In the design illustrated in Figs. 49 and 50 it will be evident that the second ejector has to deal not only with the air coming from the condenser but also with the steam used in the first ejector. By introducing a small auxiliary condenser between the two ejectors the work of the second can be much reduced and the same results, so far as air extraction is concerned, can be obtained with about half the steam consumption otherwise required. The arrangement referred to is used at Wembley, and is illustrated diagrammatically in Figs. 51 and 52. In the actual Wembley apparatus the ejectors are duplicated, one set being used as a stand-by and to give quick starting. In the auxiliary condenser the cooling water circulates round the tubes, through which the steam from the first ejector makes four passes. A horizontal after-condenser or feed heater of the surface type, extracts the latent heat from the steam leaving the apparatus. As both this condenser and the inter-condenser are cooled by the condensate from the main condenser on its way to the hotwell, the whole of the heat in the ejector steam is conserved. It will be noted that the air extracted from the condenser does not come into contact with the condensate, this being a feature which many engineers will appreciate.

The three photographs reproduced on the next page show the plant, which has been described in this article, as it appears erected on the site at Wembley. The turbine and generator are illustrated in Fig. 53, while Figs. 54 and 55 show respectively the Radojet air extraction plant with its intermediate and final condensers, and the motor driven circulating and condensate pumps at the bottom of the condenser pit.

We may mention that arrangements have been made for the installation of a full system of temperature recorders of the Cambridge and Paul type. All the sluice valves throughout the condensing plant, as well as the atmospheric exhaust valve have been supplied by Messrs. Alley and MacLellan, of Glasgow, and Messrs. George Kent, Limited, of Luton, have provided meters for measuring the amount of steam used and also the quantity of circulating water.

(To be continued.)

AIR TEMPERATURE AND HUMIDITY AND THE COMFORT OF WORKERS.—In order to study the influence of the temperature and humidity of the air upon workers, especially in mines and tunnels, the United States Bureau of Mines (Reports of Investigations, Serial No. 2563) has equipped at Pittsburgh two psychrometric rooms, 8 ft. by 17 ft. by 10 ft. insulated with 4-in. cork and plastered, and provided with air washers, humidifiers, de-humidifiers, heating and refrigerating coils and measuring instruments. The experiments of F. C. Houghten, C. P. Yaglaglou and R. R. Sayers are made by keeping the conditions in one room steady and altering the conditions slightly in the other. The two rooms intercommunicate. The experiments have so far been made only in still air.

POWER CONSUMPTION ON THE UNDERGROUND.—There is no more certain way of promoting efficiency than by letting the staff know in some quantitative manner what results they are getting, and the Underground Railways of London, in accordance with their progressive policy, have arranged that the men shall be informed by means of charts and otherwise how much power is consumed in operating the various services. Their weekly traffic circular now shows the current consumed per car-mile on the different routes, and the staff have been invited to write competitive essays on "Why the Consumption Varies on Different Lines and how it may be Reduced." Eighty per cent. of the current produced by the company is employed for train movement, and the operation of the system involves the consumption of between 800 tons and 900 tons of coal per day. The statement of the company from which we quote contains no reference to the possibility of reducing the coal consumption per unit generated at the power station by any method of letting the operating men know, shift by shift, what results are being obtained, and it may be that the introduction of some such system as that used by Mr. R. B. Mitchell at Dalmarnock would produce equally good results at Lots-road.

BRITISH EMPIRE EXHIBITION; 1,500-KW. TURBO-GENERATOR AND AUXILIARIES.

(*For Description, see Page* 425.)

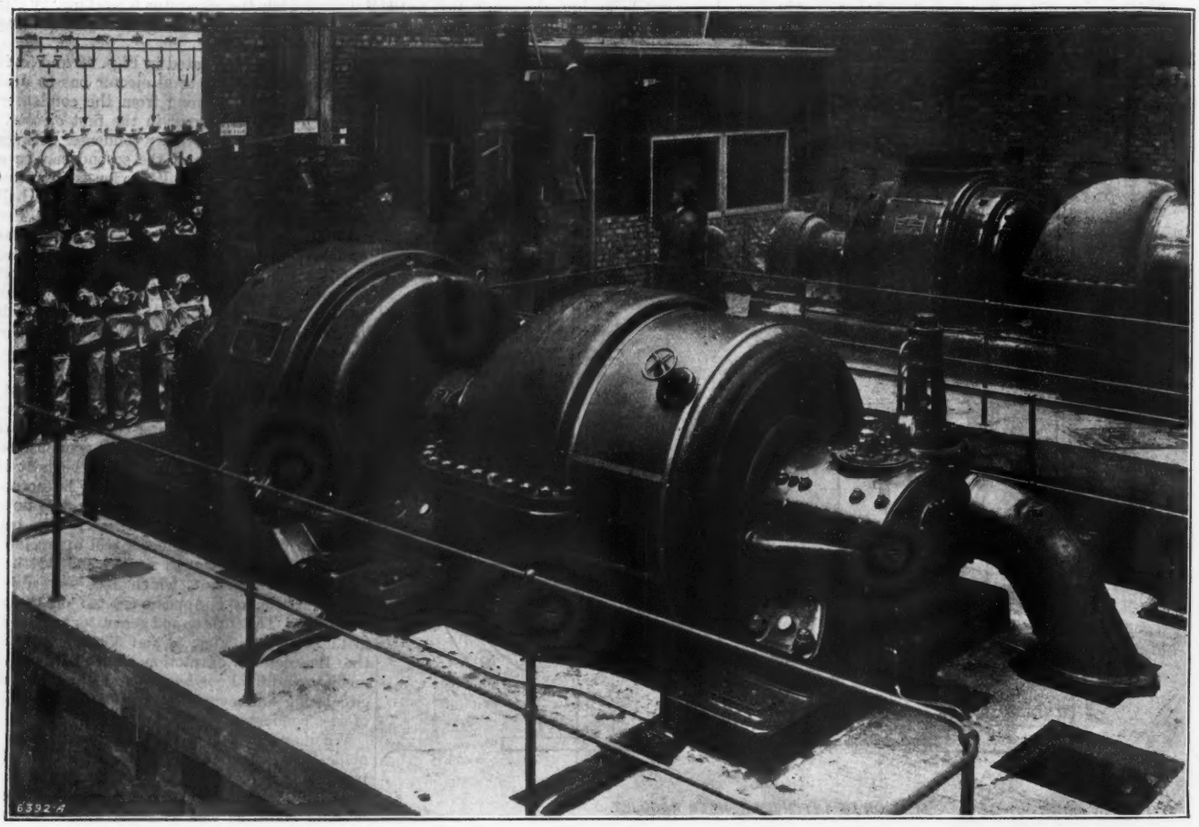


FIG. 53. HOWDEN-GENERAL ELECTRIC TURBO-ALTERNATOR ON SITE.

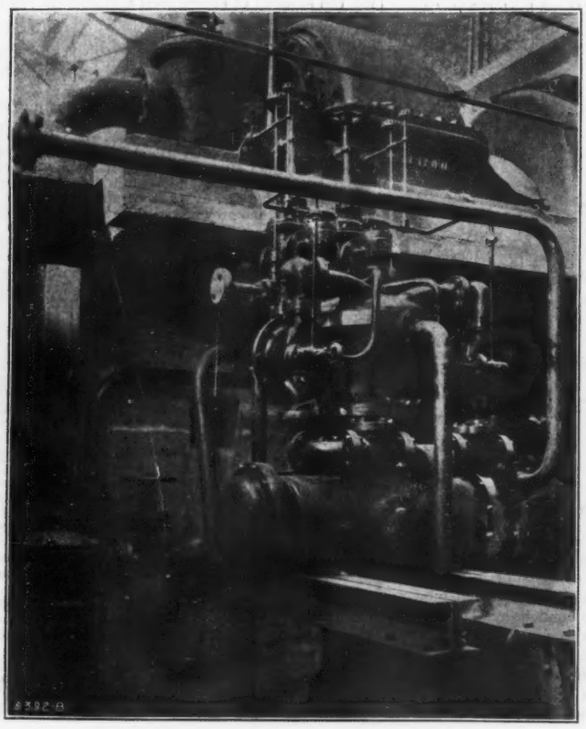


FIG. 54. RADOJET AIR EXTRACTOR APPARATUS.

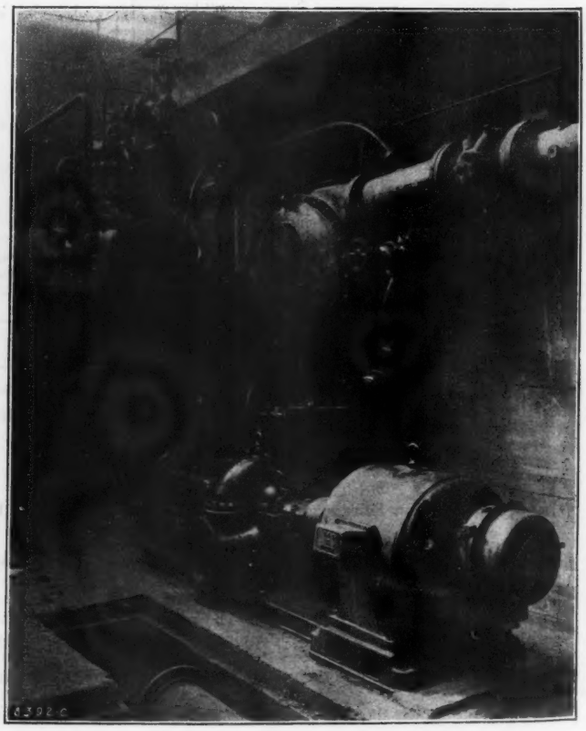


FIG. 55. CIRCULATING AND CONDENSATE PUMPS.

THE PROPERTIES OF GASES IN HIGH AND LOW VACUA.

IN concluding last Saturday his course of four Royal Institution lectures on the above subject, Sir Ernest Rutherford, F.R.S., first referred to later developments of the methods used for measuring low pressures.

The quartz-fibre gauge vibrating like a pendulum (illustrated in our Fig. 8 on page 387 of last week's issue) in the gas the pressure of which was to be determined, Sir Ernest stated, gave a somewhat rough and difficult method for this estimation. Of the more elaborate similar devices one of the simplest depended upon the reaction between two parallel discs, one of which was rotating in its plane. As the air between the two plates was moving with the plate, a tangential pull was set up tending to turn the stationary plate in the same direction. In the molecular gauge of S. Dushman, of the General Electric Company of Schenectady (Fig. 9), A was the rotating plate, turned at a high controllable speed by the induction motor GH, and C was the stationary plate suspended by the quartz fibre F, to which the mirror M was attached in the chamber B. The upper plate C would assume an equilibrium position; but the principle of the action was not the same at very low gas pressure as at ordinary pressures. At a pressure of about 0·001 mm. a molecule hitting plate A might come off in almost any direction; yet there would be a tangential component in its movement, and the molecule would transfer momentum in the direction of the rotation to plate C. The torque would be proportional to the speed of rotation, to the number of gas molecules (or the gas pressure), and to the square root of M/T, where M was the mass of the gas atom and T the absolute temperature. Down to pressures of 10^{-5} cm. the gauge was reliable; below 10^{-6} cm., however, the oscillations of the instrument became troublesome, because there was no damping.

Pressures could also be measured, Sir Ernest continued, by means of thermionic valves. If the gas within the valve were at a reasonable pressure, the electrons sent by the filament over to the grid would collide with gas molecules and produce positive ions proportional in number to the number of residual gas molecules.

Passing to the thermal conductivity of rarified gases, the lecturer remarked that it was (in vacuum-jacketed vessels for liquid air, etc.) most important that the annular jacket space should be highly exhausted. Any gas present in the jacket allowed heat rays to traverse the jacket and to volatilise the liquid air in the vessel; when this gas was gradually withdrawn from the jacket there was first very little effect; but when the gas pressure was reduced to 0·1 mm., the heat effect fell off strongly. To exemplify this Sir Ernest had charged the jacket of a Dewar vessel, containing liquid air, with air at ordinary pressure. The vessel was loosely stopped and the quietly-boiling air was allowed to escape through a tube dipping into water; it bubbled briskly. When the jacket was evacuated by the triple Gaede pump, the rate of bubbling remained unchanged for a minute, but then became very slow.

Turning to evacuation by means of charcoal, Sir Ernest said that the powerful adsorption of gases by charcoal had been known for centuries, but Dewar's discovery of 1904, that this adsorptive power was enormously increased by cooling specially prepared charcoal in liquid air, had become a most valuable asset in physical research. During the war charcoal had been prepared for gas masks by various processes from various materials; Sir Ernest used the cocoanut shell charcoal of Sir James Dewar for his demonstrations, some of which were due to Sir James. A good charcoal would adsorb 1,000 times its volume of gas; in the early days Dewar had reduced 2,000 cubic cm. of air at 2 mm. pressure to 0·0005 mm. by means of 20 grammes of charcoal. The differential adsorptive power of charcoal for different gases was, further, of great importance. The annexed table showed the adsorption of some gases per cubic centimetre of charcoal; column A gave the boiling points of the gases, column B the volumes adsorbed at 0 deg. C., and column C those volumes at — 185 deg. C., both in cubic centimetres.

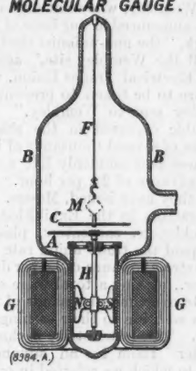
—	A.	B.	C.
	Deg. C.		
Helium	−268·6	2	15
Hydrogen	−252·9	4	135
Argon	−186·2	12	175
Nitrogen	−195·8	15	155
Oxygen	−183·0	18	230

The various gases, it would be seen, differed more at low temperatures than at the freezing point of water, and helium, which stood apart in this respect, came more into line at very low temperatures. Thus at temperatures of — 186, — 210, and — 252 deg. C., the volumes of helium and of hydrogen adsorbed under the same conditions were: helium, 2·5, 5, 160 cubic cm., and hydrogen, 137, 180, 250 cubic cm. That peculiarity was of great value for the separation and purification of gases.

As regards the mechanism of charcoal adsorption, Sir Ernest continued, we knew that the most porous charcoals were the most suitable and that the porosity depended upon the material and its treatment. It was assumed that the charcoal was full of capillary openings; the gas first rushed into these capillaries of the cold charcoal, and there followed afterwards the slower condensation on the charcoal as a whole. According to various estimates the capillaries might have diameters of 5×10^{-7} cm.; in that case 1 gramme of charcoal would have a surface of 2,500 sq. metres. The gas would probably be adsorbed in layers only one molecule in thickness; if so, 1 gramme of charcoal should be able, according to Langmuir, to adsorb 2,000 cubic cm. of gas, which figure was of the observed order of magnitude. The matter might, however, be more complex. Langmuir had also suggested that the chemical reactions during the heating of the charcoal led to the formation of long chains of carbon atoms.

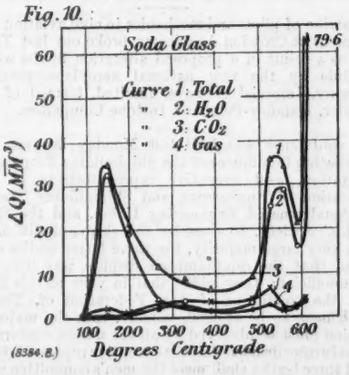
Sir Ernest proceeded to demonstrate this extraordinary adsorbing power of charcoal. The charcoal tube of a radiometer had been kept in liquid air for half an hour; when the liquid was removed, the lantern beam first failed to set the radiometer in motion, because the vacuum was too high; then the wheel turned quicker and quicker, but as the tube got warmer, more air was released from the charcoal and the motion stopped again. The whole experiment did not take two minutes. To illustrate the differential adsorption, Sir Ernest passed 300 cubic cm. of air through cooled charcoal, which adsorbed all the gases except neon (of which air contains 1 part in 100,000) and the still smaller fraction of helium; the residual gas was then driven into an electric discharge tube, which showed the reddish glow of neon. In another experiment helium gas was generated by heating samarskite in a quartz tube. It was then dried and filtered by charcoal, and the residue then showed the yellow glow of helium.

Fig. 9.
MOLECULAR GAUGE.



(8384.A.)

Fig. 10.



(8384.B.)

The difficulty in vacuum experiments was the gradual liberation of gas and moisture from the walls and materials of the apparatus, the lecturer continued. Heating an incandescence lamp bulb of 200 sq. cm. surface, after drying, for 24 hours, up to 200 deg. C. for 3 hours, Langmuir found that the following volumes, expressed in cubic millimetres, of gas were liberated: 200 of water vapour, 5 of carbon dioxide, 2 of nitrogen. After further heating to 350 deg. C., the totals were 300, 20, 4 volumes, and after raising the temperature to 500 deg. C., 450, 30, and 5 cubic mm. of water vapour, carbon dioxide and nitrogen were altogether evolved. The curves (Fig. 10) indicated that the liberation of gas, chiefly water vapour, from soda glass was particularly strong between 100 and 200 deg. C. and again between 500 and 600 deg. C., and that decomposition set in at higher temperatures. This was exemplified by heating the side tubes of various bulbs; in a few seconds the fairly high cathode ray vacuum, as indicated by the green glow of the electric discharge, gave way to striations. To get rid of the adsorbed gas was technically a great problem. In the case of Coolidge bulbs the problem was solved by heating the bulb in a vacuum furnace as high as the glass would permit, while keeping the pump going and the tungsten filament hot. Metals like tungsten bound gases like nitrogen chemically, in addition to decomposing water vapour, at high temperatures, and they thus effected a "clean-up" of the residual gas. Phosphorus, magnesium and other reagents were used for the same purpose.

Concluding, Sir Ernest Rutherford remarked that he had been unable to deal with the effects of pressure on the discharge of electricity, which he would have to leave to another opportunity.

THE THERMAL EFFICIENCY OF INTERNAL COMBUSTION ENGINES.*

ENGINEERING progress demands the revision of standards and ideals from time to time, and the Committee which has recently been appointed to revise the report of a previous committee on the tabulation of the results of steam engine and boiler trials (revised 1913) will, by virtue of the extension of its terms of reference, require to consider certain questions dealt with by an earlier committee which reported on the efficiency of internal combustion engines (1905).

The 1905 Committee reported in favour of the "Air standard" as the then best ideal with which to compare the performance of internal combustion engines, using air as the standard ideal working fluid, the specific heat of which was assumed to be constant. The committee stated definitely that these conclusions were only regarded as a temporary expedient, until such time as the requisite data was obtained, which would render possible a restatement of the ideals to be aimed at. Sir Dugald Clerk, Professor Burstall, the late Professor B. Hopkinson, and others, have done research work, which has widened our knowledge, and the critical and analytical work of others, all help materially towards more rational definitions of ideals and standards.

The ideal simple standard cycles applicable are the well known "Constant-pressure" and "Constant-volume," together with the "Diesel" and "Dual combustion," the last two being combinations of the two first mentioned. The thermal efficiencies of these cycles are stated usually in terms of temperature or of the compression ratio, but it is proposed to compute the efficiency in terms of the energy supplied and rejected in each cycle. As regards the working fluid, it appears possible to replace the imaginary air with constant specific heat, by means of a gas mixture whose properties approximate more closely to those possessed

* Abstract of a note prepared by Mr. G. James Wells on the report to the Committee on Tabulating the Results of Heat Engine and Boiler Trials, dealing specially with standards of comparison in connection with the Thermal Efficiency of Internal Combustion Engines, to be read at a joint meeting of the Institutions at the Institution of Civil Engineers, on Tuesday next.

by the actual gas mixture found in internal combustion engines. The work of Sir Dugald Clerk, the British Association Committee on Gaseous Explosions, and a formula proposed by Dr. Stodola, are examined and shown to be more closely in agreement than might be expected from the numerical values attached to the constants, and upon these a proposal is based that an imaginary fluid may be postulated with properties that give on the whole a fair approximation to the actual truth, certainly much closer than the air standard can possibly achieve.

The solution suggested is that, by means of a diagram (nomographic), and the data given by a mean indicator diagram, the temperatures, changes of total energy and internal energies may be found, in a manner somewhat similar to that employed in conjunction with a Mollier Chart in connection with turbine problems. A sample table is added giving the internal and total energies reckoned from absolute zero of temperature, a sort of table of properties of gases for the use of internal combustion engineers. An entropy chart is also combined with the nomogram, which enables the actual engine heat cycle to be readily compared with the suitable ideal cycle, thus giving directly a visual impression of the engine's departure from the ideal, and a quantitative measure of the relative efficiency.

The chart thus built up is then tested by means of published tests, of a gas engine, and two Diesel engines. In the case of the gas engine, three tests were published and efficiency figures found by means of the diagram were 0·360, 0·359 and 0·357, as compared with the figure 0·3535 computed and published at the date of the tests. The diagram gave a mean pressure of 89 lb. per square inch, which agrees exactly with that obtained from the cards. Similar results are obtained in the latter case.

Finally it is claimed that the time has arrived when engineers should take the fullest advantage possible of the advances made in the knowledge of the behaviour of the gases in internal combustion engines, to revise their standards and ideals, for use in internal combustion engine problems.

INDUSTRIAL NOTES.

THE strike of the London tramway and omnibus workers came to a close on Monday night, and the services were resumed on Tuesday morning, following a ballot which showed the following figures: For acceptance of the terms and resumption of work, 9,428; against, 4,377, or a majority in favour of 5,051. The terms offered by the employers and on which the ballot was taken were as follow: The "uniform" staff are to receive 6*s.* advance as basic wage and no change in bonus wage until the cost of living has dropped eight points below the cost-of-living index figure of 75. This covers motormen, conductors, regulators and inspectors. The other grades are to receive an advance of 4*s.* on bonus wage, no change to be made in the present bonus until the cost of living shows a similar drop to the above. A committee is to be appointed to consider the question of night work and other conditions.

The following is an abstract of the final offer made by the Mining Association to the Miners' Federation: Standard profits shall consist of 15 per cent. of standard wages, instead of 17 per cent. as at present. The surplus, after deduction from proceeds of standard wages, costs other than wages and standard profits, shall be divided between wages and profits in the proportions of 87 per cent. to wages and 13 per cent. to profits, instead of 83 and 17 as at present. The general minimum percentage on standard wages shall be increased from 20 to 32·5. The wages of no adult, able-bodied, day-wage workman to fall below a figure of 40 per cent. above the standard of the lowest-paid class of day-wage workman. The amounts of the existing maximum subsistence wages and allowances already fixed by the District Boards are to be increased by one-eighth. There shall be effective recoupment of deficiencies below standard profits, but only one-third of any future surplus available for this purpose shall be so applied, the remaining two-thirds shall be divided between wages and profits in the agreed proportions, any balance of the deficiency being carried forward. The owners undertake to deal in the districts with cases of anomalies in the wages of men at or near the level to which the lowest-paid class of workmen will be brought by their proposals. The owners are prepared to agree that pensions shall not be treated as a cost of production, but that the cost shall be borne by them.

The owners' terms were considered at a delegate conference of the Miners' Federation, at the close of which the following statement was issued:—

"By a majority of the Executive Committee, the following resolution was put to the conference: That it be a recommendation to the members to reject the terms now offered as providing no solution of the miners' wage question generally, nor giving the immediate relief so vitally necessary, and calling upon the Government to institute an inquiry into the wages of miners (*a*) compared with their wages in 1914, (*b*) compared with the cost of living index figure, and (*c*) compared with the wages now prevailing in industry generally. The voting in favour of the resolution was 502,000.

"An amendment was moved that the owners' proposals be submitted to the districts, with a recommendation for acceptance, and also a recommendation for an inquiry by the Government into the whole economic conditions of the mining industry. There voted in favour of the amendment 271,000."

This last figure is significant as showing that there is no unanimity among the miners' delegates with regard to the refusal of the owners' proposals.

It was further stated that the ballot to be taken by the members of the Miners' Federation on the acceptance or rejection of the owners' terms is not to be understood as a strike ballot. The ballot vote will be taken on the resolution carried by the conference, and a clear majority in its favour will carry it. Should an inquiry be refused then a strike vote would be taken, in which case this other ballot would require a two-thirds majority.

The electricians employed at the British Empire Exhibition, at Wembley, who went out on strike following the dispute announced in our issue of March 7, have returned to work, "the non-unionist electricians having been cleared-off the Wembley site," according to the officials of the Electrical Trades Union, who add that "precautions are to be taken to prevent non-unionist electricians being sent to Wembley." On Tuesday, far worse trouble occurred in the shape of an unauthorised strike of several thousands of building-trade operatives; these men suddenly left work to enforce a claim for an advance of 2*d.* per hour. In the course of a statement they have issued, Messrs. McAlpine and Sons, the contractors to the Exhibition, say that all craftsmen, bricklayers, carpenters, plasterers, plumbers, etc., are paid the trade union rate of 1*s.* 8*d.* per hour, plus an extra allowance of 1*s.* per day, equivalent to 1½*d.* per hour., making a total wage of 1*s.* 9½*d.* per hour. Owing to overtime, thousands of men had been able to earn an addition to their earnings of from 30*s.* to 2*l.* per week. This latter strike is closely connected with the builders' claim for an advance of 2*d.* per hour in wages, to which we referred in our last issue.

A strike of pilots and mechanics in civil aviation employment at Croydon Aerodrome broke out last Tuesday, as a result of a proposed alteration in the wages schedule by the new national aeroplane-operating company, Imperial Airways, Limited, formed of the Daimler, Handley-Page and Instone Companies.

A conference was held last Monday between the Negotiating Committee of the Shipbuilding Employers' Federation, and executive representatives of the Federation of Engineering and Shipbuilding Trades, the Amalgamated Engineering Union, and the Shipwrights' Society, to consider the shipyard difficulty. By a very large majority, the three latter bodies confirmed that the Southampton dispute was irregular and unofficial; they added that in view of this decision, the conditions of the Federation of Trades would have to be applied, namely, that the majority decision must be observed by all the unions concerned. It was further decided that the executive representatives of all three bodies shall meet the men's committee with a view to obtaining a resumption of work. The executive representatives are visiting Southampton to-day for that purpose. The employers have agreed eventually to postpone the posting of lock-out notices until to-morrow, the 5th inst. If there is a lock-out, it will take effect on and after Thursday, the 10th inst., in respect of members of those unions whose Southampton members have not returned to work by Tuesday, the 8th inst.

According to *The Iron Age*, New York, which quotes another journal, a Labour Party is not possible in the United States for the reason that there is no "caste system" in the country. Moreover, in the United States the members of labour unions constitute only about 10 per cent. of those who are gainfully occupied, the unions covering railway workers, coal miners, and building trade artisans; a Labour Party would therefore consist of these operatives only. It is general knowledge, our contemporary adds, that railway jobs have been multiplied, whereby there is less service rendered per man than there should be. Every one has heard that there are too many coal miners, that they do not work enough days in the week. It is equally well recognised that the cost of building, which affects every one, is unreasonably high on account of union restrictions. A Labour Party would mean publicity, and publicity has not been improving the standing of the labour unions in the minds of the other 90 per cent. of those who work.

Our American contemporary also states that swollen wages are held responsible by the Union Pacific Railway for the absorption of all the increase in gross earnings of the railways between 1917 and 1922. That increase is given as 1,567 million dollars. To offset this, railway employees received 918 millions of additional wages; the additional cost of coal was 135 millions, mostly due to increased miners' wages; additional taxes absorbed 122 millions; materials and supplies took 500 millions—this again being due in large measure to enhanced wages. The sum of the four items of cost increases was 1,675 million dollars, or considerably greater than the increase in gross earnings. Evidently the stockholders and bondholders did not benefit from the increased gross earnings of the railways in which their money is tied up.

Orders and contracts in connection with the London, Midland and Scottish Railway's expenditure of 14,000,000*l.* for renewals and reconstruction work have been allocated from day to day with beneficial results on the labour market in the many districts over which this work is distributed. The orders for new locomotive boilers number 700, of which 70 have been allocated to Messrs. Vickers, Limited, Barrow, 50 to the Vulcan Foundry, Limited, Newton-le-Willows, 30 to Kerr, Stuart and Co., Stoke; 50 to Ruston and Hornsby, Limited, Lincoln; and 50 to Beyer, Peacock and Co., Limited, Manchester. The remainder will be made in the company's own workshops as follows: 200 at Crewe, 100 at Horwich, 100 at Derby, and 50 at St. Rollox. The company's carriage and wagon-building programme comprises 15,000 goods wagons of various types and 518 passenger train vehicles, of which 46 are ambulance vehicles converted into brake and parcels vans. Five thousand two hundred of the goods wagons will be obtained from outside firms, but 9,800 will be made in the company's works at Earlestow, Wolverton, Derby and Newton Heath. In connection with this work large orders for material have been given to numerous firms throughout the country.

In presenting the third annual report and accounts, for the year 1923, of the National Institute of Industrial Psychology, the chairman, Mr. H. J. Welch, recalled that the main object of the institute was to make work less wasteful and easier of accomplishment—first, by the improvement of the methods and conditions of work, and secondly, by the selection of work and workers according to the latter's natural abilities. Research during the year carried out by the Institute alone and in conjunction with other bodies embraced problems relating to colliery work, illumination, ventilation, manual and bodily movements, &c. Practical work was done in relation to methods and conditions of work; the selection and training of workers in colliery, engineering, glass, and other establishments. In addition, many vocational tests of individuals were made and lectures and addresses given. Current investigations included one commissioned by the Mining Association of Great Britain in relation to work in collieries, the other being in connection with vocational guidance and selection.

WORKMEN'S COMPENSATION ACTS.

We have received from H.M. Stationery Office an admirable memorandum on the Workmen's Compensation Acts, 1906 and 1923. The anonymous author states that the object of the memorandum is to set out briefly and in plain language the main provisions of the Acts; but he has avoided the common mistake of trying to explain the subject by dealing separately with each section of the Acts. Instead, he gives a comprehensive survey of the subject as a whole. He states clearly to what injuries the Acts apply, what persons are entitled to compensation, who is liable to pay it, the amount of the compensation and how it is to be paid, the procedure for claiming and recovering it and for reviewing and redeeming weekly payments, and for the settlement of disputes by medical referees; and he explains clearly the application of the Acts to industrial disease.

Since the Amending Act of 1923 was passed a few months ago employers generally have made commendable efforts to acquire a working knowledge of the law of Workmen's Compensation, and some of the leading employers' organisations have prepared and issued to their members memoranda explaining the effect of the new Act. The Home Office memorandum, however, gives in 18 or 20 pages one of the best outlines of the subject which we have seen, and we should advise employers and the officials of employers' organisations to read and study it. It seems a pity that the author's name is not given, but no doubt its anonymity is in accordance with the traditions of the Civil Service. From what we have read, however, on the law of Master and Servant, we think we could identify the author.

The author has, perhaps, scarcely made it clear that the increased amounts payable under the Act of 1923 are

not payable in the case of accidents which happened before January 1, 1924. The statement on this point on page 11 is liable to be read as applying only to injuries resulting in disablement and not to injuries resulting in death, and why does the author write on page 1 "more necessary," and on page 13 "verbally" when he means "orally"?

Prints of the pamphlet can be obtained from H.M. Stationery Office (Price 1*d.* net, postage extra) at Imperial House, Kingsway, W.C. 2; 28, Abingdon-street, S.W. 1; York-street, Manchester; 1, St. Andrew's-crescent, Cardiff; and 120, George-street, Edinburgh.

NOTES ON NEW BOOKS.

THE simplicity and usefulness of the treatment of many applied mathematical problems by the methods of the calculus has led to the devotion of some time at the end of a boy's schooldays to the acquisition of some knowledge of the processes and their application. There can be no doubt that this action, replacing the older one of spending the time on the strengthening of the powers of technique on formal algebra and trigonometry, has much to recommend it. In a volume recently published by Messrs. Edward Arnold and Co., London, two masters at public schools, Mr. R. C. Fawdry, M.A., of Clifton, and Mr. C. V. Durell, M.A., of Winchester, have submitted a very good course of study in this useful work. The book is entitled "*Calculus for Schools*," and is sold at 6*s.* 6*d.* net. As the initial difficulty encountered by teachers in introducing the subject is the grasping of the significance of the equation of a curve, the authors have devoted the first part of the book to driving home the principles involved in the process, prior to dealing with the notation, or what may be termed the "mathematical shorthand" of the calculus. The scope of the treatment may be indicated by the statement that it covers the requirements of the qualifying examination for the Mechanical Science Tripos at Cambridge. Great care has been shown in the provision of exercises and examples, the working of which will provide the student with a good knowledge of the practical applications of the subject and the variety of work in which its methods ensure simplification of the solution of problems.

In almost every kind of work in which the disruptive energy of explosives is used to achieve some purpose of practical utility, the black powder of early efforts has been replaced by high explosives. This change has been dictated by the necessities of economy, both in cost of explosive and in labour. When such a change in practice takes place it is imperative that information be placed at the disposal of those who are reluctant to take advantage of improvements, because of their limited knowledge of the methods of employing them and the extent of their action. For these reasons Mr. W. Gerard Boulton has written a very readable account of the modern practice under the title "*Blasting with High Explosives*," and this book Sir Isaac Pitman and Sons, Limited, of Parker Street, Kingsway, London, have recently published, at a price of 5*s.* net. It is an eminently useful little volume of just over 100 pages, and gives an indication of the composition and explosive strength of various standard productions and the sizes of cartridges adopted by the manufacturers. The variety of work undertaken by their use is, of course, great, and not only are chapters provided on representative examples, but also on fuses, detonators and exploders. Demolition, quarrying, driving tunnels and mining operations are dealt with separately, and the improvement of ground for agricultural purposes by the loosening produced by dynamite explosions, an important and economical process, is also a subject of treatment.

With the publication of the "*Hütte, Taschenbuch für Betriebsingenieure*" the Akademische Verein "Hütte" has started upon a new venture. The "*Hütte, des Ingenieurs Taschenbuch*" has often been mentioned in these columns. Some months ago we referred to the 24th edition of this standard pocket book for German engineers. The publication before us is especially compiled for works' engineers and managers, and is offered in one volume of 1,273 pages, illustrated by 1,431 text figures (Berlin: Wilhelm Ernst und Sohn), whilst the other pocket book extends over three volumes. Some of the sections, on materials, their testing and strength, measuring in general, and modern tools, &c., would naturally be found in any engineer's pocket book. But the general sections of the old "Hütte" on mathematics and mechanics have been left out, and the editor, Dr. Ing. A. Stauch, and his numerous collaborators, have paid particular attention to the modern aspirations for unification in standards and tolerances, and further to the design and organisation of works, transport problems, repairs, hygiene and welfare, profit sharing, wages agreements and social features generally. There is a special section on wood working machines; otherwise metals receive possibly too much preference. A minor peculiarity hardly to be recommended is that the various authors are indicated by letters of the alphabet which have nothing to do with their initials.

When the electric furnace some thirty years ago made calcium carbide a commercial article, a great future was predicted for the carbide and for the acetylene generated from it. The development of the acetylene industry has hardly reached the stage expected. As a raw material for the chemist acetylene is still little in demand, and the acetylene burner has not really proved a formidable rival to the electric lamp and the gas lamp. Yet acetylene has become indispensable to the engineer and metallurgist and has helped on another gas industry, the oxygen industry, and all work connected with the tools and the oxy-acetylene blow-pipe. This last though merely a modification of the old-fashioned blow-pipe, has developed into a most useful metal-welding and cutting device. What can be done in this line, and how it should be done, Mr. E. A. Atkins, M.I.Mech.E., explains in his volume on "*Electric Arc and Oxy-Acetylene Welding*" (London: Sir Isaac Pitman and Sons, Limited, price 7*s.* 6*d.*). Mr. Atkins is director of research to Messrs. Rylands Brothers and Messrs. Pearson and Knowles, of Warrington, and lecturer on welding at the Municipal Technical School, Liverpool. He has compiled his volume as a practical handbook for works managers, welding operators and students. The lack of chemical formulæ does not therefore call for comment. But the chemistry is weak, and some remarks are of too homely a style. He dismisses oxy-hydrogen welding, for instance, because "in the burning of hydrogen, water vapour is always formed, this when it comes into contact with molten or hot iron causing the formation of oxide." He does not say what becomes of the hydrogen in the acetylene flame. There are two chapters on "don'ts"; "don'ts" for electric-arc welders and for oxy-acetylene welders. Most of the advice given there and elsewhere in the book is no doubt good, but 17 pages of short paragraphs, each beginning with "don't" makes rather dull reading. The illustrations, diagrams and also photographs of good and bad welds, are much to the point.

In almost every type of engineering work considerable progress was made before there was any exact appreciation of the principles involved, and chemical engineering was no exception to the general rule. Only in recent years has any attempt been made to gauge the requirements of machinery for chemical processes with any degree of precision and to discover the reasons for the success attained with the use of specific plant, which was commonly installed as the result of experiences based upon the process of trial and error. Nowadays the position is very different, for rational designs must be produced and the outputs must be guaranteed before the scheme is proceeded with. Under such conditions exact knowledge is requisite. This has been made possible by experimental investigations already conducted in the many fields of services, and by the greatly extended knowledge that is available regarding the properties of the materials used. In a recent work, "*Principles of Chemical Engineering*" (McGraw-Hill Publishing Company, Limited, London, 25*s.* net), the three authors, Professors W. H. Walker, W. K. Lewis and W. H. McAdams, of the Massachusetts Institute of Technology, have dealt with the underlying principles upon which the rational design and the operation of the equipment depend. Once these fundamentals are appreciated, the successful design of plant to meet the requirements of specific cases may be raised from the level of good luck to that of exact predetermination. In this volume the authors have wisely concentrated on those processes which are common to all the chemical industries rather than on those of restricted use or of great deviation from the general methods because of peculiar conditions. Descriptions of plant are provided, and their yields are considered in a way which is of great service to those who have to design suitable equipment for a specific purpose and output. In addition, illustrative problems and their solutions are given to facilitate the appreciation of the matter and make the successful accomplishment of the designers' task a matter of greater ease.

Although steel structures sometimes bear stresses under which they ought to break down according to all theory, and although the interpretation of test results remains highly controversial, every engineer wants his materials tested to a certain extent. But the engineer has so many matters to study and to attend to that he must leave the science of testing to specialists. On the other hand, he wants to understand the test certificates. There are plenty of books on the subject, and they may be grouped under two categories, the special treatise on certain methods of testing, frequently good in its way, but too specialised or theoretical, and the general treatise, frequently poor and little more than a reproduction of somebody else's work somewhat modernised. The "*Werkstoffprüfung für Maschinen- und Eisenbau*," by Dr. G. Schulze and E. Vollhardt (Berlin: Julius Springer; price 1·90 dollars), seems to represent the recommendable medium. Dr. Schulze is a member of the Materialprüfungsamt at Berlin-Dahlem, and much of the apparatus which is described in the 185 pages of the volume and illustrated by 213 diagrams, some of which are good, are naturally those which A. Martens and E. Heyn and their collaborators introduced and used at this Institution. Mr. Vollhardt is lecturer at the Beuthe School of Berlin. There are only book references at the end of the volume. Technological tests, in which no power measurements are taken, and chains, ropes and belts are not neglected, but more might have been said on fatigue testing.

The substitution of mechanical for manual processes in the conduct of simple operations appeals to many, who conclude that some material advance must necessarily follow from the installation of new apparatus. It may be doubted whether the success is always so complete as those who scheme new processes persuade themselves. Automatic telephony, the possibility of calling up a subscriber without the intervention of human agency, may appeal to many who have suffered from the incompetency or superciliousness of the lady operator, and to many more by reason of the ingenuity exhibited, the acquisition of complete control over complicated mechanism, and the certainty of action that is implied. But whether the success, economical and mechanical, is as great as anticipated, whether the elimination of error and the saving of time and temper is absolutely ensured, are among the doubts we entertain as we read Mr. Crotch's little work on *The Elements of Automatic Telephony* (E. and F. N. Spon, London and New York, 1924, price 3*s.* 6*d.* net), written with the intention of supplying operators with an easy means of acquiring the practical working knowledge of the subject they require. "Operators" here must mean the public, for it is they who will have to set in motion the devices that make the necessary connections. We doubt if in this sense the public will show the slightest interest in the relative merits of the systems proposed, respectively, by the Automatic Telephone Company, the Siemens Company and the Relay Automatic Company, the three that are described here, more especially as they have no choice in the selection of the system assigned to their use. This indifference is by no means to be attributed to the author, whose diagrams are clear, if a little complicated for the novice, and whose explanation adequately indicates the differences of arrangement and construction of each. But how many of the thousands of subscribers who use telephones could explain their mechanism or the principles on which they act, or in case of failure detect the cause or supply a remedy. What is looked for is certainty and efficiency in action, with simplicity in the method of operating. These are points on which we should have liked more information, and the author, from the information acquired as a Post Office official, might have enlightened us. Apparently, he expects all to go well and with the utmost regularity, for we have not seen indicated, with the necessary degree of fulness, how the machinery intimates automatically its failure to perform, other than in the case of an "engaged" wire. Nor do we see how a subscriber, who is conscious that he has made a mistake in his fingering, can rectify the error. Neither do we perceive the means for calling an exchange other than that to which he is attached, or to get on to a trunk line. There are other operations which seem to call for explanation, but it must be remembered that this volume is concerned only with the elements of automatic telephony, and we await the further developments which may be vouchsafed to us in good time.

THE INSTITUTION OF ELECTRICAL ENGINEERS, NORTH MIDLAND CENTRE.—The following nominations have been made by the committee: Chairman, Mr. T. B. Johnson, Superintending Engineer to the Post Office; Vice-chairmen: Mr. S. Derwen Jones, Borough Electrical Engineer, Batley, and Mr. W. E. French, the University, Leeds; Hon. Secretary, Mr. J. D. Bailie, of Messrs. C. A. Parsons and Co., Limited, Leeds. Six nominations were also made to the committee.

INSTITUTION OF MECHANICAL ENGINEERS.—Vol. II of the proceedings of the Institution of Mechanical Engineers for 1923, has recently made its appearance. It contains the papers presented at the Summer Meeting in Glasgow, with the discussions thereon, the latter including that which took place on "Clyde Marine Oil Engines," at the adjourned meeting held last winter in London. The volume also contains the presidential address by Sir John Dewrance; the Thomas Hawksley Lecture by Sir Westcott Abell, Mr. W. J. Kearton's paper on Mercury for Binary Fluid Turbines; the paper by Professor Gibson and Mr. Baker on Exhaust Valve and Cylinder Head Temperatures, and others by graduates and others selected by the Council for publication.

BRITISH CHEMICAL STANDARDS—IRON AND STEEL.

IN a former article (ENGINEERING, April 5, 1918, page 374) we gave particulars of the scheme which has for its object the preparation of chemical standards of iron and steel, a scheme which has been operating since 1916, following preliminary work carried out by Messrs. Ridsdale and Co., in their laboratory, at Middlesbrough. This scheme, viewed from the standpoint of engineers, and the interpretation of chemical specifications in relation to analytical work, were dealt with in a paper read by Mr. C. H. Ridsdale last month, at a joint meeting held in Middlesbrough of the Cleveland Institution of Engineers, the Newcastle Section of the Society of Chemical Industry, and the Institute of Chemistry. Mr. Ridsdale called attention to the expense involved in the rejection of material and in the delay in accepting it, adding that when the interpretation of specifications was unnecessarily rigid, the country's difficulties in competing increased. He quoted from Mr. Samuelson's presidential address to the Iron and Steel Institute delivered two years ago to the effect that "two railways, over whose lines many of the same trains run, have rail specifications which vary by 0·02 per cent. for both phosphorus and sulphur; if one of these railways be not endangering the lives of its passengers, the other is needlessly increasing the cost of making steel rails, and restricting the use of certain ores."

In putting certain facts before the meeting, Mr. Ridsdale said he was not attempting to relax specifications. He recognised that engineers in the strictness they exercised were aiming at maintaining a well-earned reputation for high quality and safety; they specified chemical limits which, from experience or from what metallurgists had led them to believe, they considered desirable. For carbon, manganese and silicon the specifications usually quoted an upper and a lower limit, arranged to give certain strengths and toughnesses, and to meet the manufacturer's unavoidable working margin, but for what were regarded as injurious impurities only a maximum limit was stated, so low that its effect was negligible. Engineers then looked to the chemist to tell them whether or not the material came within the figures. For example, sulphur or phosphorus in steel were "not to exceed 0·03 per cent.," and the maker, of course, wanted to work to this. The engineer gave him for section, length and weight, exact drawings, gauges, templates, measurements, &c., all having definite standard values, and definite allowances were made for variation from them. For compostion, however, the maker had nothing definite to go upon; all that was given him and all he had to work to was a figure that had no exact meaning, and its value was determined arbitrarily, after the steel had been made, by analytical operations subject to ever-varying personal and other factors, so that another test of the same sample might yield a slightly different result. Although, therefore, the maker's own chemist might find the material right, he could never be sure it would not be rejected.

It might be replied that the differences of the buyer's, the maker's or the reference chemist's results from absolute accuracy were so slight as to be of no importance. This might be true as far as the actual effect on the properties of the material was concerned, but such small differences near the border line—quite within the range of working of good chemists—might be enough to cause rejection.

Analytical chemistry was able to determine composition with considerable accuracy, and owing to this and to the extremely small quantities dealt with, testing by means of it was set to a very high degree of exactitude. If chemists had not been capable of testing so accurately, specifications would not have been so stringent. For this same reason exaggerated importance was apt to be attributed both to the influence of small quantities of impurities and to trifling differences in results; no allowance was officially recognised for differences in analytical figures.

Here, Mr. Ridsdale emphasised the advantages to be derived from the composition figures being specified in terms of a definite standardised sample, the values of which had already been determined. A good range of such standard-analysed samples was now available, and in their preparation important factors which tended to create differences between the results of chemists in ordinary work were removed.

The British Chemical Standards movement tentatively suggested a tolerance slightly above one-half the range of variation found with work carried out under exceptionally favourable conditions. The tolerance could be visualised in terms of length and weight. Every engineer could readily conceive 1/100th of an inch, but 200 inches or 16 ft. 8 in. were not measured to 1/100th of an inch, nor was 1667 ft. to 1 in.; nor was a ton measured to 1¼ oz. Yet that was the equivalent of what a chemist did, and it gave some idea of the smallness of the tolerances. Mr Ridsdale added that in order not to confuse the issue he would not discuss the question as to how far such a difference in sulphur or phosphorus as 0·005 per cent., even if it were an increase, could detrimentally affect the material, when even the 0·03 per cent. specified was regarded as a negligible amount. The practice of reporting the results of analyses to the third decimal place had no doubt arisen from the fact that chemists were men of very precise habit; when they worked out a weight or a reading, their love of accuracy led them to take the figure down to a negligible point. Definite standards were now available, and the engineer ought to refer to them as a check on the works or the reference chemist's analysis; both makers and chemists ought to regard these standards not merely as a convenience to be supplied or used at option, but as a necessity which they had a right to demand. Mr. Ridsdale, in conclusion, referred to the recommendations of the British Engineering Standards Association, and thought that those of the British Chemical Standards should take effect in the same way.

CALENDAR.—The Metropolitan-Vickers Electrical Company, Limited, who have made it their practice to issue a calendar from April to March, have sent us a copy of a highly decorative one for 1924–1925.

SEMI-PORTABLE AIR COMPRESSING AND PUMPING SETS.

THE PARSONS MOTOR COMPANY, LIMITED, ENGINEERS, SOUTHAMPTON.

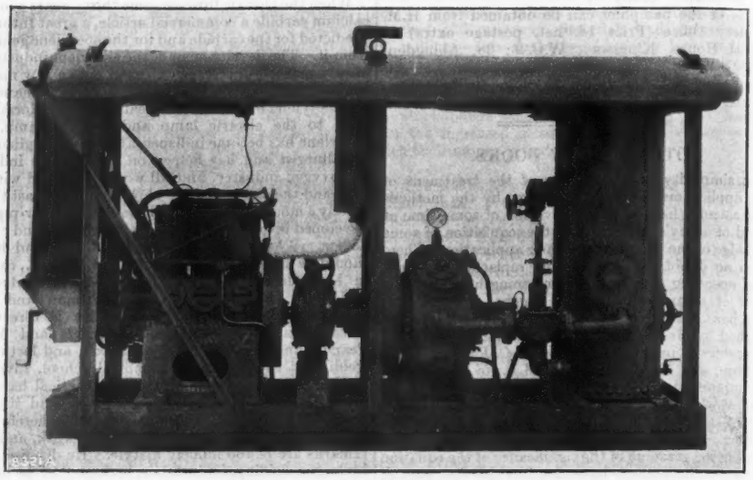


FIG. 1.

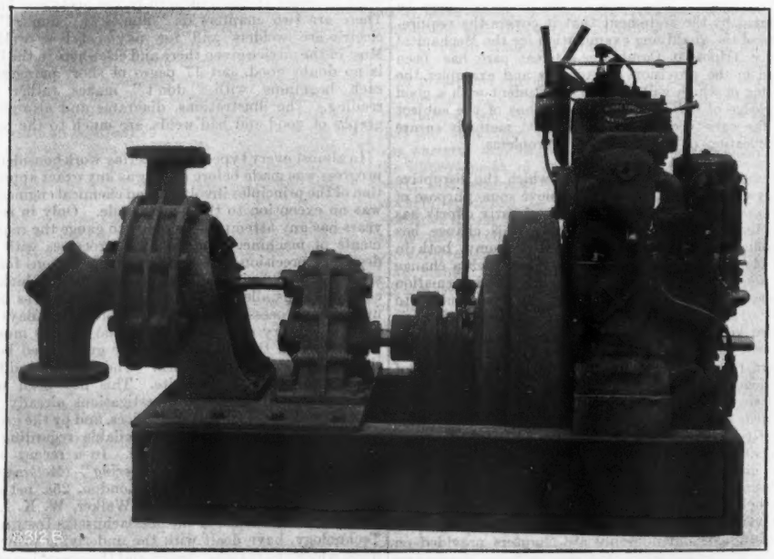


FIG. 2.

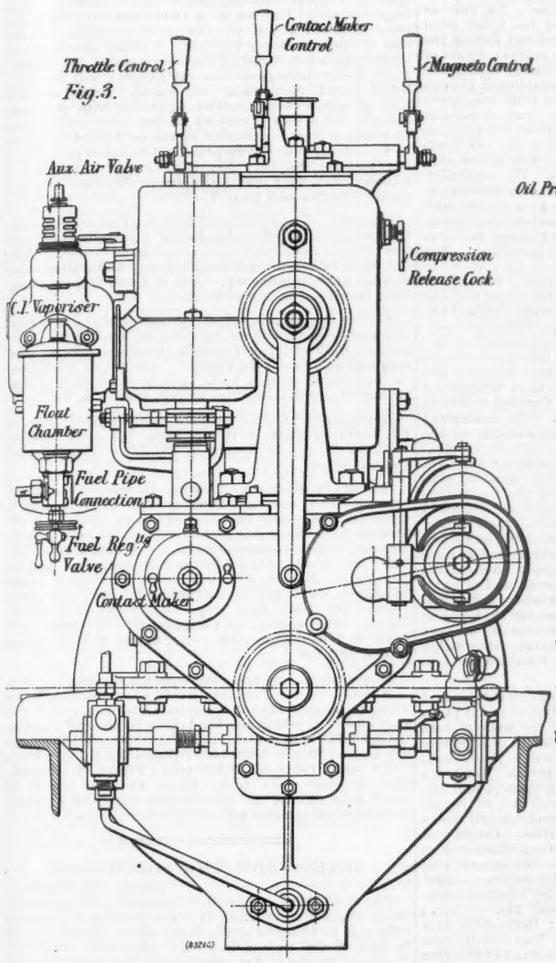
SEMI-PORTABLE AIR COMPRESSING AND PUMPING SETS.

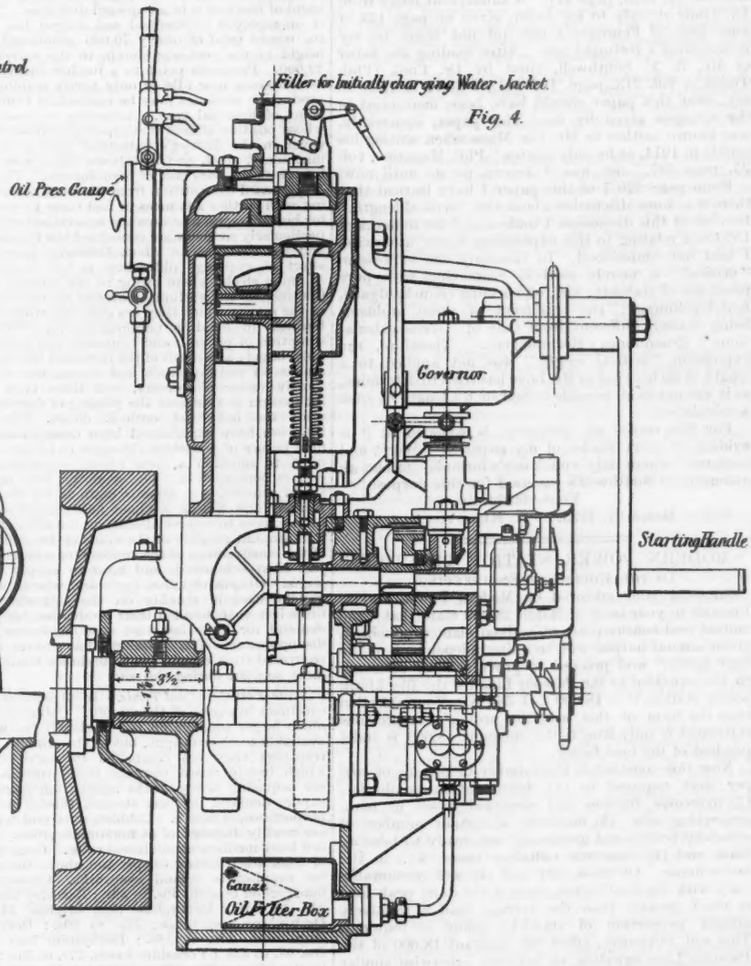
THE use of pneumatic tools is so convenient in connection with shipyards, structural engineering works, boiler shops road-breaking contracts, &c., that a considerable development has taken place in the manufacture of portable and semi-portable air-compressing plants which can be placed as near as possible to the scene of operations and removed when the work is finished. Among the firms who have specialised in such plants is the Parsons Motor Company, Limited, of Town Quay Works, Southampton, whose petrol-driven compressors are largely in use for driving the rock drills employed in breaking up the concrete foundations of the London streets. For street work the sets are mounted on wheels, but for some duties it is occasionally more convenient for them to be of the semi-portable type, which can be swung into position for working by a crane. Fig. 1, above, illustrates a self-contained unit of this description which has recently been supplied by the Parsons Company to the order of the Crown Agents for use on the Nigerian Railway. It is similar to, but somewhat larger than, two others previously supplied by the firm for the same railway.

The power unit is the standard Parsons three-cylinder engine, rated at 21 b.h.p. In this case it is arranged

SINGLE CYLINDER PARAFFIN ENGINE FOR DRIVING PUMP.

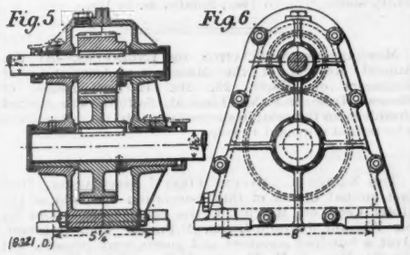
CONSTRUCTED BY THE PARSONS MOTOR COMPANY, LIMITED, ENGINEERS, SOUTHAMPTON.





to run on petrol. The engine is fitted with forced lubrication and drilled crankshaft, and a circulating pump provides for effective circulation of the cooling water. An enclosed governor is fitted for speed regulation, and there are the usual hand controls. The radiator for cooling the circulating water is specially large to meet the requirements of a tropical climate. Next to the engine will be seen the makers patent reducing-gear and caliper clutch, by which the engine speed of 1,150 r.p.m. is reduced to a speed of 460 revolutions for the compressor. The latter, constructed by Messrs. Reavell and Co., of Ipswich, is of their quad-ruplex type, with a displacement of 120 cub. ft. of free air per minute. It delivers air at a pressure of 100 lb. per square inch for operating pneumatic hammers, &c. The set is self contained in every respect and complete with fuel tank, silencer and other necessary equipment. The air receiver is mounted on the same bed. It is fitted with the usual gauges, also a special air-governor and a valve-box for various delivery pipes. The whole plant is covered with a stout sheet-metal roof; there are side curtains for protecting the machinery from the weather, and shackles for lifting purposes are provided at the top of the uprights of the framing. Plants such as the one illustrated have been supplied for a large variety of purposes both at home and abroad, and they are not only highly efficient, but are capable of running at full power for practically any length of time.

An application by the Parsons Motor Company, Limited, of one of their single cylinder engines to drive a centrifugal pump through gearing, the whole forming a semi-portable pumping unit, is illustrated in Fig. 2, opposite. The engine is illustrated in detail in Figs. 3 and 4, above, and the arrangement of gearing in Figs. 5 and 6. The pump is a 3-in. centrifugal by Messrs. Gwynne's Engineering Company, Limited, of Hammersmith. The engine runs at 900 r.p.m., and the interposition of the gearing increases the speed of



the pump to about 1,700 r.p.m., thus enabling a smaller and lighter pump to be used than would otherwise be the case. The gears are totally enclosed and run in oil. The whole plant is mounted, as will be seen on a bed of channel steel welded solidly together, and it can therefore be moved about readily and put down anywhere without the alignment of the parts being disturbed. The set is capable of delivering about 50 tons of water per hour against a head of 50 ft. The particular plant illustrated has been supplied to Messrs. Drysdale, of Gravesend, and installed on a fresh-water barge for supplying fresh water to shipping in the river.

The engine, shown in Figs. 3 and 4, is of the makers standard single cylinder paraffin type, with pump lubrication, governor and the usual hand control. The flywheel is fitted with a metal-to-metal cone clutch, allowing the engine to run free when required. The engine develops 7 b.h.p. at its normal speed, and is so simple in construction that its details will be readily followed from the very clear drawings which we are enabled to reproduce.

THE MANCHESTER STEAM USERS' ASSOCIATION.—The Annual Report of the Committee of Management to the members of the association shows that on December 31, 1923, the membership was 1,854, the works numbering 5,169 and the number of boilers under inspection 11,678. After meeting all expenditure, both ordinary and special, the net surplus in favour of the year was £5,297.

BRIDGE FOR HOLLAND.—The Vice-Consul at Amsterdam reports—in view of a possible call for tenders which may take place in the near future should the plan be adopted—the proposal to build a bridge 1,150 metres (3,773 ft.) long, with an up gradient of 28 millimetres per metre (one in 35·7) over the Y river connecting Amsterdam with the North Sea Canal. A few further particulars regarding this proposal may be obtained by interested United Kingdom firms on application to the Department of Overseas Trade, 35, Old Queen-street, London, S.W. 1, quoting reference 22498/F.W./E.C. 2.

CONTRACTS.—The Yeovil Rural District Council has recently let the contract for the new main from South Petherton, for the Martock Water Supply, to Messrs. William Sparrow, Ltd., Martock, Somersetshire, at the price of 2,690*l.* 15*s.* 11*d.* Twelve British firms sent in tenders, the highest being 3,800*l.* The engineers are Messrs. Martin and Roberts, 44, St. George's-square, Westminster.—The Vickers-Spearing Boiler Company, Limited, 20, Kingsway, Westminster, W.C.2, have during the last two weeks, been successful in securing the following contracts for boiler equipment, namely:—Aberdeen Corporation Electricity Works, two boilers, 36,000 lb.; Dover Corporation Electricity Works, one boiler, 30,000 lb.; Kingston-on-Thames Corporation, one boiler, 30,000 lb.—Messrs. Ed. Bennis and Co., Limited, 28, Victoria-street, S.W. 1, have recently booked numerous and important contracts for their chain grate stokers, smokeless chain grates, sprinkler stokers, coal elevators, coal-handling plants, coal and ash handling plants, coal bunkers, conveyors, coking stokers, hoppers, &c., for electricity stations, textile manufacturers, dyers, iron and steel works, collieries, municipal and other installations, many of which are repeat orders.

"STRESSES IN REINFORCED PIPES."

To the Editor of Engineering.

SIR,—In your issue of January 18, page 87, you published a letter by me in reference to a contribution by Dr. Cook, on the above subject in your issue of October 12, 1923, page 477. A subsequent letter from Dr. Cook in reply to my letter, given on page 154 of your issue of February 1 last did not come to my notice until a fortnight ago. After reading the paper of Mr. R. V. Southwell, cited by Dr. Cook (Phil. Trans. A vol. 213, page, 187–244), I don't hesitate to say, that this paper should have been mentioned in the synopsis given by me. This paper, apparently, was known neither to Mr. von Mises when writing his article in 1914, as he only quotes "Phil. Magazine, vol. 25, page 687," nor was it known to me until now.

From page 226/7 of this paper I have learned that there was some discussion about the "critical length." In view of this discussion I understand the remarks of Dr. Cook relating to this expression, which, otherwise, I had not understood. In Germany the expression "critical" is merely used in connection with pure problems of stability, viz., of buckling (Knickaufgabe, Knickrechnung); the treatment of these problems being entirely different from that of "stress-calculations" (Spannungs - Rechnungen). Therefore, the expression "critical length" was not applied to a length of such a kind as Mr. Love has tried to determine, as it was not at all possible to find such a length by such a calculation.

For this reason all confusion is avoided as it is evident to every reader of my paper in "Werft und reederei," where only von Mises's formula—in fact an extension of Southwell's—is used for this purpose.

Yours faithfully,

Baden, March 27, 1923. KURT VON SANDEN.

"MODERN POWER STATION PRACTICE."

To the Editor of Engineering.

SIR,—In your editorial on Modern Power Station Practice in your issue of March 28 you state that "the annual coal consumption of a given plant producing a given annual output will be quite independent of the load factor," and proceed to prove this by reference to the equation to the Parsons Line for the Blackburn power station, $C = 18{,}600 + 1{\cdot}540\ K$. Your assertion that the form of this equation proves your previous statement is only true if the constant 18,600 is independent of the load factor.

Now this constant is the number of pounds of coal per shift required to (1) drive station auxiliaries, (2) overcome friction and electrical losses in main generating sets, (3) maintain a certain number of stand-by boilers and generating sets ready to take up load, and (4) overcome radiation losses, &c., in the boiler-house. Of these, (3) and (4) will presumably vary with the load factor, since if the daily peak load is much greater than the average load a relatively greater proportion of stand-by plant is required. This will, obviously, affect the constant 18,600 of the Parsons Line equation as between otherwise similar stations working on widely different load factors. Your argument as to the effect of load factors on capital charges is, of course, perfectly sound, and supports the contention that in industrial plants particularly, which shut down at night and over week-ends, the basis for the determination of load factor should be the yearly output divided by the number of hours in a year, and not the number of running hours—since, of course, capital charges are never "shut down." Also the coal consumed at nights and over week-ends in maintaining steam and starting up will appreciably affect the first constant in the Parsons equation.

A further point is that if, as you state, load factor affects capital charges only, then it ought to be calculated on a basis of total capacity of installed plant multiplied by number of hours in a year, and not on actual yearly output. It would appear that for a true comparison between stations the load factor might be calculated as at present from

$$\frac{\text{Total annual output}}{\text{Maximum load} \times \text{Number of running hours}}$$

and that a second factor—

$$\frac{\text{Total annual output}}{\text{Installed capacity} \times \text{Number of hours in a year}}$$

be also employed as affording a basis for the comparison of the part of the cost of a unit of power which is due to capital charges. Yours faithfully,

HUGH H. BURNESS.

University College of Swansea, Engineering Department, Mount Pleasant, Swansea, April 2, 1924.

[The constant (18,600 in the case of Blackburn) represents the amount of coal which would be burnt per shift if the load on the station fell to zero, and is deduced graphically from the quantities required at greater loads. It is clearly dependent upon the amount of plant which would be in service under such conditions, and this will be constant for any given station.—ED.E.]

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Conditions vary greatly in the steel and engineering industries. In works visits, restricted output is to be found side by side with production which reaches a high level. In a general sense, however, the trend of business is in an upward direction. The number of unemployed in Sheffield and district has fallen from the record total of nearly 70,000 announced during the height of the post-war slump, to the current figure of 23,000. Prospects point to a further steady absorption of craftsmen now idle or only partly employed, though production statistics may be misleading from the standpoint of financial gain. According to trade organisers whose position affords them special facilities for judging, never in the district's industrial history was so much machinery, steel, and metalware being sold either at a loss or at the bare cost of manufacture. The possibility of increased competition from the Continent, synchronising with further advances in fuel costs to meet demands for higher wages, increases the uncertainty of the outlook, particularly so far as are concerned the finished products and the materials in which Germany specialises. The effect of exchange differences is felt most acutely in common steels, where owing to the growing strength of Continental underselling, contracts are not being renewed at the rate at which they are expiring, while much of the business in hand is unremunerative. Sheffield's consumption of pig iron and hematites has grown considerably, largely as a result of the increased demands made on makers of railway stock and stores, but deliveries are mostly under old orders, and there is a widespread inclination to postpone the placing of forward contracts until the industrial outlook clears. The armament branches have experienced keen disappointment at the final failure of persistent attempts to induce the Government to sanction a more liberal expenditure on light cruiser construction. The work on hull armour, gunshield armour, and armour castings for the battleships Rodney and Nelson is about half completed. Sheffield firms expect to receive allocations for about 1,000 tons of hull armour, roughly of the value of 100,000*l.*, in respect of the construction of the cruisers for which tenders have just been submitted, and later to supply 16-in. naval shells. Output of axles, tyres and wheels, and of automobile steel is notably on the upgrade. Individual firms last year doubled their production for 1921. The demand for high-class tool steel continues to be very disappointing. The market has never thoroughly recovered from extravagant purchases made on Government account during the war.

South Yorkshire Coal Trade.—In all sections the demand continues in excess of the supply. Collieries could put a much larger tonnage on the market if the wagons were available to clear output, but in the absence of adequate transport they are compelled to restrict production, which barely meets contract commitments. Railways are acquiring heavy stocks against emergency, and the export demand for best steams, though not of record proportions, is active. Cobbles, nuts and washed slacks are readily disposed of at maximum prices. House coal is a busy medium at unaltered rates. Open market sales of coke are realizing 5*s.* per ton above the agreed level for supplies to inland ironworks. Quotations:—Best handpicked branch, 36*s.* to 39*s.*; Barnsley best Silkstone, 34*s.* to 36*s.*; Derbyshire best brights, 31*s.* to 35*s.*; Derbyshire best house, 27*s.* to 29*s.*; Derbyshire best large nuts, 27*s.* to 28*s.*; Derbyshire best small nuts 20*s.* 6*d.* to 23*s.*; Yorkshire hards, 27*s.* to 30*s.*; Derbyshire hards, 25*s.* to 28*s.*; Rough slacks, 12*s.* 6*d.* to 15*s.* 6*d.*; Nutty slacks, 12*s.* to 14*s.*; Smalls, 8*s.* to 10*s.*

MANCHESTER ASSOCIATION OF ENGINEERS.—At the Annual Meeting of the Manchester Association of Engineers on March 28, Mr. Herbert Bates, of Messrs. Hulse and Co., Limited, Salford, was elected President for the year, in succession to Mr. Cecil Bentham, who retired pursuant to rule.

THE NATIONAL "SAFETY FIRST" ASSOCIATION.—The first annual dinner of this Association was held at the Hotel Cecil on March 28, the chair being taken by Sir William Joynson-Hicks, M.P., the hon. treasurer. Over a hundred members and guests were present, but the Rt. Hon. J. H. Thomas, M.P., and Rt. Hon. John Wheatley, M.P., were prevented from attending on account of their preoccupation with the strike of the tram and 'bus men, or as Mr. H. E. Blain humourously explained, "by circumstances over which they appeared to have no control." Mr. Blain as vice-president of the Association, speaking from the recent close connection with London traffic, stated that there were now thousands of drivers who set themselves deliberately to avoid accidents. Many had been entirely free from accidents for five or six years. Traffic accidents in London had not grown proportionally to their increase in provincial towns where no "Safety First" campaign had been started. Last year 6,500,000*l.* had been paid in cash for workmen's compensation for industrial accidents, apart from legal and medical expenses, and taking no account of lost time. Sir William Joynson Hicks stated that in the streets of London, every day, eight people were killed and 200 injured by traffic accidents. Sir William J. Larke, director of the National Federation of Iron and Steel Manufacturers, struck a serious note, saying that he wished to see the principle of "Safety First" applied to the country as a whole. In many ways we were steering straight to bankruptcy. It was suicidal for the country to dissipate its resources by endeavouring to provide a higher standard of living than was really earned; the better things of life must be worked for, not whined for.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Home transactions in Cleveland pig iron have been on quite a substantial scale, and export trade though not large, has shown some improvement. The result is that producers have disposed of practically all their rather heavy stocks, and are now in quite a strong position. Upward movement in quotations has not driven customers out of the market, and hope is entertained that stabilisation will be established round about rates now ruling. Prices are still such as admit of successful competition with producers abroad, and a very gratifying feature is the reduced loss on make to local ironmasters by the fall in cost of output to the advances in selling price of Cleveland pig. No. 1 has become 96*s.* 6*d.*; No. 3 g.m.b., 92*s.* 6*d.*; No. 4 foundry, 91*s.* 6*d.*; and No. 4 forge, 90*s.* 6*d.*—all f.o.t. makers' works, and f.o.b. Tees.

Hematite.—The position as regards East Coast hematite has not changed for the better to the same extent as has Cleveland pig, but improvement is noticeable. There has been rather more business doing, and values show decided upward tendency. Nos. 1, 2 and 3 are realizing 99*s.*, and No. 1 is put at 100*s.*

Foreign Ore.—There is little or nothing doing in foreign ore, and it is difficult to ascertain on what terms transactions could be put through. Consumers have good supplies, and are off the market. Sellers bare quotations on best rubio at 24*s.* c.i.f. Tees, but would doubtless favourably entertain offers at less than that figure.

Blast-furnace Coke.—Durham blast-furnace coke is not quite so weak as it has been, but good medium qualities can still be bought at 28*s.* 6*d.* to 30*s.*, delivered to local users.

Manufactured Iron and Steel.—In some branches of manufactured iron and steel a little more inquiry is reported, but many firms are short of work, and are anxious to book orders to follow on expiring contracts. Principle market quotations stand:—Common iron bars, 12*l.*; iron rivets, 14*l.*; packing (parallel), 9*l.*; packing (tapered), 12*l.*; steel billets (soft), 9*l.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 13*l.* 10*s.*; steel ship, bridge and tank plates, 10*l.* 5*s.*; steel angles, 10*l.*; steel joists, 10*l.*; heavy steel rails, 9*l.*; fish plates, 13*l.*; and galvanized corrugated sheets, 18*l.* 10*s.*

Shipments of Iron and Steel.—March shipments of iron and steel from the Tees totalled 80,437 tons, 32,427 tons being pig iron, 2,435 tons manufactured iron, and 45,575 tons steel. Scotland was the largest receiver of pig iron, taking 6,140 tons; whilst Belgium imported 5,493 tons; the United States, 3,826 tons; Wales, 3,000 tons; Italy, 1,810 tons; Denmark, 1,425 tons; France, 1,180 tons; and Germany, 711 tons. India with an import of 9,871 tons was by far the heaviest customer for steel, New Zealand coming next with 2,297 tons.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—A fresh endeavour is being made to bring about a resumption of night working by the coal trimmers and tippers at the South Wales docks. A conference of the tippers and their employers, the Great Western Railway, has been held, when an offer was made to the men conditional upon their recommencing work on the third shift. The coal trimmers have, however, sprung a surprise on the Shipping Federation by making an application for an increase of 13½ per cent. on the present trimming rates, which would have the effect of bringing the rates to within 20 per cent. of the National Trimming Tariff of 1920. The demand has been considered by the Cardiff District Federation, and the representatives on the Trimming Board have received instructions to resist the claim of the men. It is, in fact, understood that the employers will press for a reduction of 16⅔ per cent., or 66 per cent. above the pre-war rates. Meanwhile, a considerable number of steamers are waiting to load coal, and as collieries are well booked up with orders, buyers experience difficulty in securing supplies, and prices are firmly upheld on the basis of 32*s.* 6*d.* for best Admiralty large and 22*s.* 6*d.* for best steam smalls.

German Competition.—At the annual meeting of the Cardiff Chamber of Commerce, Mr. C. L. Clay, the retiring president, said that the coal trade last year suffered from depression less severely than most trades as a result of the disorganisation caused by the French occupation of the Ruhr. Unfortunately, for us the position had changed, and the Ruhr now was not only delivering increased quantities of reparation coal, but was also selling its free coal in large quantities at prices which were materially below what could be quoted from South Wales. His eyes were widely opened to this fact quite recently, when he found that a French contract had been allotted to Germany at more than 2*s.* 6*d.* per ton below the South Wales price. Severe competition was also being felt from America and even Holland had come into the market as a new competitor. The coal trade was in fact full of difficulties apart from labour troubles.

THE MELBOURNE TECHNICAL SCHOOL.—The prospectus for the current year issued by this school gives evidence of great activity in all branches of technical studies. The prospectus includes courses in mathematics, mechanics, electricity and many trades.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—No improvement of any kind falls to be recorded in connection with the Scottish steel trade this week, and the demand for material is a bit easier. Some buyers who could enter the market and place some business are holding back, saying that a little further delay will not upset them very much. Meantime there is a great want of confidence and no one can see the exact turn things will take, with the result that buyers are adopting the mark-time policy and employment at the works is suffering. Inquiries are not plentiful, particularly for ship plates, but sectional material is in slightly better demand. The black-sheet makers are still doing fairly well and their order-books show quite a good tonnage, but neither this nor any other branch of the industry will improve to any extent until more settled conditions prevail in the labour world. Export trade is quiet. Prices are unchanged and are as follow:—Boiler plates, 13*l.* 10*s.* per ton; ship plates, 10*l.* 5*s.* per ton; sections, 10*l.* per ton; and sheets, 12*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—The West of Scotland malleable-iron trade is practically without change this week. There is a fair amount doing in the way of demands against old contracts, but new business is most difficult to secure. In the re-rolled steel branches there is a moderate amount of activity, but very keen prices require to be accepted. Prices are inclined to get the turn easier, but "Crown" bars are still called 12*l.* 10*s.* per ton, delivered Glasgow stations.

Scottish Pig-Iron Trade.—A dull tone is still general in the Scottish pig-iron trade and movement is very limited. The demand for foundry grades has not improved, but sellers are hopeful of fixing up some of the inquiries which have lately been going round, although to secure these keen quotations have to be submitted. Hematite is slow of sale, but deliveries against contract are fairly good. The current prices are as follow:—Hematite, 5*l.* 2*s.* 6*d.* per ton, delivered at the steel works; foundry iron No. 1, 5*l.* 5*s.* per ton, and No. 3, 5*l.* per ton, both on trucks at makers' yards.

Shipments of Scottish Pig-Iron.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, March 29, amounted to 3,330 tons. Of that total 3,240 tons was for overseas destinations and only 90 tons went coastwise. For the corresponding week of last year the figures were 6,115 tons foreign and 204 tons coastwise, making a total shipment of 6,319 tons.

Wages in the Iron Trade Advanced.—The joint secretaries of the Scottish Conciliation and Arbitration Board have received intimation from Sir John M. MacLeod, C.A., Glasgow, that he has examined the employers' books for January and February, 1924, and certifies that the average net selling price brought out is 12*l.* 4*s.* 6*d.* per ton. This means an increase of 2½ per cent. in the wages of the workmen engaged in the Scottish manufactured iron trade.

Shipbuilding.—Steady work in the various shipbuilding yards in Scotland since the boilermakers' returned to work, after the lock-out last year, has resulted in a large number of vessels being brought forward to launching point. It so happened that many were put into the water during last month, and the figures given below would tend to the thought that the industry was really busy. That is not the case, but signs are not wanting of a slight revival, although the threatened lock-out next week of all federated shipyard workers over the Southampton affair, has brought a slight gloom over the industry. The figures for the past month are as follows:—

	Vessels.	Tons.
The Clyde	16	58,218
The Forth	2	2,840
The Tay	—	—
The Dee and Moray Firth...	—	—
Total	18	61,058

The Clyde total for March is more than for the months of January and February combined, and brings the output for the year to date up to the respectable figure of 105,742 tons. Tonnage for the quarter is quite a good average over recent years, and is much better than last year, when the total was 68,204 tons. Quite a number of new contracts were placed during March, but more might have been secured had builders been able to offer firm prices, based on to-day's costs. That has, unfortunately, been found impossible, because of the demands of labour in the shipbuilding industry, and of possible higher costs for fuel.

STANDARD BALL JOINTS.—The British Engineering Standards Association have recently issued their report on Ball Joints (No. 5020–1924). By using the standard ball joint on carburetter and magneto control, the irritating slackness which prevents fine adjustment due to the old method of joining the control rods is entirely eliminated. Automobile ball joint No. 1 is of simple and inexpensive design, whilst ball joint No. 2 is designed for heavier work. The material used in the manufacture of these fittings is not specified and is left to the discretion of the manufacturer. The dimensions of the standard ball joints will ensure interchangeability, which, after all, is the key note of standardisation. Copies of the report may be obtained from the British Engineering Standards Association, Publications Department, 28, Victoria-street, London, S.W.1, at the price of 1*s.* 2*d.* post free.

NOTICES OF MEETINGS.

THE INSTITUTION OF MECHANICAL ENGINEERS.—To-day at 7 p.m., at Storey's Gate, Westminster. Informal Meeting. Subjects for discussion, "Mechanical Methods of Boiler Firing," by Mr. H. P. Gaze (resumed); and "Rational Design of Mechanical Draught for Combustion Purposes," to be introduced by Major S. Utting. Friday, April 11, at 6 p.m., at Storey's Gate, S.W. 1. General Meeting. "The Relation of Air-Consumption to Brake Horse-Power in Internal-Combustion Engines; Road and Flight Tests," by H. Moss, D.Sc., A.R.C.S., D.I.C.

THE INSTITUTE OF TRANSPORT.—Monday, April 7, at 5.30 p.m. in the Lecture Theatre, Institution of Electrical Engineers, Victoria Embankment, W.C. 2. "Organisation of Traffic and Locomotive Departments in Relation to Running," by Mr. H. A. Watson, C.B.E., M.V.O.

THE SOCIETY OF ENGINEERS (INCORPORATED).—Monday, April 7, at 5.30 p.m., in the Apartments of the Geological Society, Burlington House, Piccadilly, W. "Gas-Firing (Flame Control)" by Mr. A. C. Ionides.

THE ROYAL SOCIETY OF ARTS.—Monday, April 7, at 8 p.m., at John-street Adelphi, W.C. 2. Cantor Lecture, "Certain Fundamental Problems in Photography," by Dr. T. Slater Price (Lecture III). Wednesday, April 9, at 8 p.m. Ordinary Meeting. "The Free Pendulum," by Mr. Frank Hope-Jones, M.I.E.E.

THE INSTITUTION OF RUBBER INDUSTRY.—Monday, April 7, at 8 p.m., at the Engineers' Club, Coventry-street, W. 1. "Improvements in Education in the Rubber Industry," by Dr. T. J. Drakeley. "The Buyer Criticises the Manufacturer," by Mr. H. F. Trevillion.

THE INSTITUTE OF MARINE ENGINEERS.—Tuesday, April 8, at 6.30 p.m., at 85-88, The Minories, Tower-hill, E. 1. Specially for Juniors. "Observations on a 20,000 ton ship with Oil Engines and Electric Propulsion," by Mr. P. J. Higgs, Wh.Sc.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, April 8, at 6 p.m., at Great George-street, S.W. 1. Extra Meeting. Joint meeting with the following bodies: The Institution of Mechanical Engineers, The Institution of Electrical Engineers, The Institution of Naval Architects, The Institute of Marine Engineers, The North-East Coast Institution of Engineers and Shipbuilders, The Institution of Engineers and Shipbuilders in Scotland, The Institute of Chemistry of Great Britain and Ireland, The British Electrical and Allied Manufacturer's Association, The British Engineers' Association, which are co-operating in the work of the Special Committee on Tabulating the Results of Heat-Engine and Boiler Trials. The following subject, introduced by Mr. George James Wells, Assoc.M.Inst.C.E. will be submitted for discussion:—"Standards of Comparison in Connection with the Thermal Efficiency of Internal-Combustion Engines."

THE INSTITUTE OF METALS: NORTH-EAST COAST LOCAL SECTION.—Tuesday, April 8, at 7.30 p.m., in the Electrical Engineering Lecture Theatre, Armstrong College, Newcastle-on-Tyne. Annual General Meeting.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, April 8, at 5.30 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C. 2. "The Crude Oils of Burmah and Assam," by Mr. W. J. Wilson, F.I.C., A.C.G.I.

THE INSTITUTION OF ELECTRICAL ENGINEERS: NORTH MIDLAND CENTRE.—Tuesday, April 8, at 6.45 p.m., at The Hotel Metropole, King-street, Leeds. Annual General Meeting.

THE INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH CENTRE.—Tuesday, April 8, at 7.30 p.m., at The Rooms, 207, Bath-street, Glasgow. Annual General Meeting. "Some Researches on the Safe Use of Electricity in Coal Mines," by Professor W. M. Thornton, O.B.E., D.Sc.

THE INSTITUTION OF NAVAL ARCHITECTS.—Annual Meeting, Wednesday, April 9, to Friday, April 11, in the Lecture Hall of the Royal United Service Institution, Whitehall, W.C. 2. Wednesday, April 9, at 11 a.m., Address by the President, His Grace the Duke of Northumberland, C.B.E., M.V.O. "Strategical and Tactical Considerations Governing Warship Design," by Admiral of the Fleet Sir Doveton Sturdee, Bart., G.C.B., K.C.M.G., C.V.O., LL.D. Wednesday evening, at 7.30 p.m., Annual Dinner in the Grand Hall of the Connaught Rooms, Great Queen-street, W.C. 2. Thursday, April 10, at 11 a.m., "The Future of Sea Transport," by Mr. Archibald Hurd; "Development of the Airship, with Special Reference to Transport," by Commander C. D. Burney, C.M.G.; "Sea-borne Coastal Trade," by Sir Alfred Read; afternoon at 3 p.m., "Results of Some Rolling Experiments on Ship Models," by Mr. M. P. Payne; "The Drift of Ships Caused by Rolling Among Waves," by Professor K. Suyehiro, D.Eng.; evening at 8 p.m., "Application of Steam Turbines to Auxiliary Machinery," by Mr. R. W. Allen, C.B.E.; "High Elastic Limit Mild Steel and its General Applications," by Mr. F. G. Martin, B.Sc., and Mr. A. T. Wall, A.R.C.Sc. Friday, April 11, at 11 a.m., "Further Experimental Work on Diesel Engines," by Engineer-Commander R. Beeman, C.M.G., R.N.; "Vibration of Ships," by Mr. H. W. Nicholls; "The Torsion of Ships," by Mr. G. Vedeler, M.Sc.; afternoon at 3 p.m., "The Effect of Wind and Waves on the Propulsion of Ships," by Mr. J. L. Kent; "The Effect of Length on the Skin Friction of Flat Surfaces," by Mr. T. E. Stanton, D.Sc., and Miss D. Marshall; "Skin Friction Resistance and the Law of Comparison," by Mr. Shigenmitsu; "The Analysis of Ship Resistance," by Mr. J. Tutin, B.Sc.

THE RADIO SOCIETY OF GREAT BRITAIN.—Wednesday, April 9, at 6 p.m., at the Institution of Electrical Engineers, Victoria-embankment, W.C. 2. Informal Meeting. Mr. N. F. Fogarty, A.M.I.E.E., will open a discussion upon "The Use of Rectified Alternating Current as a Substitute for Accumulators and Dry Batteries in Receiving Circuits."

THE INSTITUTION OF RAILWAY SIGNAL ENGINEERS.—Wednesday, April 9, at 6.30 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C. 2. "A Survey of Eastern Signalling," by Mr. A. C. Rose.

THE NEWCOMEN SOCIETY.—Wednesday, April 9, at 5.30 p.m., at Prince Henry's Room, 17, Fleet-street, E.C. 4. Paper: "Ambrose and John Crowley—Citizens and Ironmongers of London, 1682–1728," by Mr. W. A. Young.

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, April 9, at 5 p.m., at 49, Cromwell-road, South Kensington, S.W. 17. "Glaisher Stand *versus* Stevenson Screen," by Mr. I. D. Margary, M.A. "A Lens for Whole Sky Photographs," by Mr. Robin Hill. "The Significance of Repression Equations in the Analysis of Upper Air Observations," by Mr. F. J. W. Whipple, M.A., F.Inst.P.

THE INSTITUTE OF METALS: LONDON LOCAL SECTION.—Thursday, April 10, at 8 p.m., at the Institute of Marine Engineers, 85-88, The Minories, Tower-hill, E. 1. "Failure in Metals and Alloys," by Mr. G. H. Gulliver, D.Sc.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, April 10, at 6 p.m., in the Lecture Theatre of the Institution, Victoria-embankment, W.C. 2. Ordinary Meeting. "Power Circuit Interference with Telegraphs and Telephones," by Mr. S. C. Bartholomew.

THE INSTITUTION OF MINING AND METALLURGY.—Thursday, April 10, at 5.30 p.m., at the Rooms of the Geological Society, Burlington House, Piccadilly, W. 1, Annual General Meeting. Presidential Address by Mr. Humphrey M. Morgan, D.Sc.

THE INSTITUTION OF LOCOMOTIVE ENGINEERS (LONDON): MANCHESTER CENTRE.—Friday, April 11, at 7 p.m., at the College of Technology, Sackville Street, Manchester. Lecture. "Some impressions on the Manufacture of Superheaters," by Mr. R. W. Whittle.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, April 11, at 9 p.m. Evening discourse will be delivered by Professor Jocelyn Thorpe on "Colours, Stains and Dyes."Afternoon Lectures, April 10, at 5.15 p.m. Dr. E. J. Allen on "Scientific Research on Sea Fisheries" (Lecture II). Saturday, April 12, at 3 p.m., Dr. Charles Singer, on "Leonardo Da Vinci as a Man of Science" (Lecture II).

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, April 11, at 7.30 p.m., at 39, Victoria-street, S.W.1. Ordinary Meeting. Discussion of paper on "Water Tube Boilers," delivered by Mr. L. M. Jockel, on March 14.

THE INSTITUTE OF METALS: SHEFFIELD LOCAL SECTION.—Friday, April 11, at 7.30 p.m., in the Non-Ferrous Lecture Room of the University, St. George's-square, Sheffield. Annual General Meeting. "The Protection of Aluminium by Electro-Plating," by Mrs. A. Vellan and Professor C. H. Desch, F.R.S.

BRAZING OUTFIT FOR USE ON AIRCRAFT.—An interesting item in the equipment of the Vickers "Vulture" Amphibious Seaplane now engaged on a flight round the world, is a small brazing and soldering set, which has been included in order to render the expedition as independent as possible in the matter of effecting light repairs *en route*. The apparatus, which includes two blowpipes and a small cylinder of dissolved acetylene—all enclosed in a neat leather case, was supplied by Messrs. Allen-Liversidge, Limited, 106, Victoria-street, S.W.1, who have also furnished the pilot, Squadron-Leader Maclaren, with a list of nearly 50 places on his route where the supply of dissolved acetylene can be replenished.

THE OPPAU EXPLOSION.—The programme of the meeting of the Faraday Society to be held on Monday, April 14, at 8 p.m., in the rooms of the Chemical Society, will include a report on an investigation of the chemical, physical and explosive properties of Oppau ammonium sulphate-nitrate, by Sir Robert Roberston and Dr. G. Rotter, with appendices by Dr. H. H. Thomas, Mr. A. L. Hallimond and Sir William Bragg. A short introduction by Sir Richard Threlfall will precede the report, giving briefly the conclusions of the Chemistry Research Board as to the causes of the Oppau explosion, which took place on September 21, 1921. Advance copies of the papers will be available (price 2*s.* to non-members) and application for them should be made to the Faraday Society, 10, Essex-street, Strand, W.C. 2.

THE LIFE OF ROLLS.—In the course of his presidential address to the Cleveland Institution of Engineers, Mr. H. B. Toy stated that the life of a chilled roll varied very considerably, depending to a great extent upon the skill of the user, the heat, quality and thickness of the steel being rolled, but in exceptional cases a pair of chilled rolls have rolled over 80,000 tons of steel plates before being scrapped. The life of sheet rolls was, of course, shorter, as it was not possible to roll the sheets with water running upon the rolls, as was the case with plate rolling. The manufacture of grain rolls had been improved very much in recent years by the use of alloys, and it was not uncommon for grain rolls to produce 2,000 tons of rails in one finishing groove without dressing, whereas only a few years ago 250 tons was considered to be good work.

HIGH-SPEED WOOD-PLANING MACHINE.

CONSTRUCTED BY MESSRS. THOMAS WHITE AND SONS, LIMITED, LAIGHPARK, PAISLEY.

(*For Description, see Page* 445.)

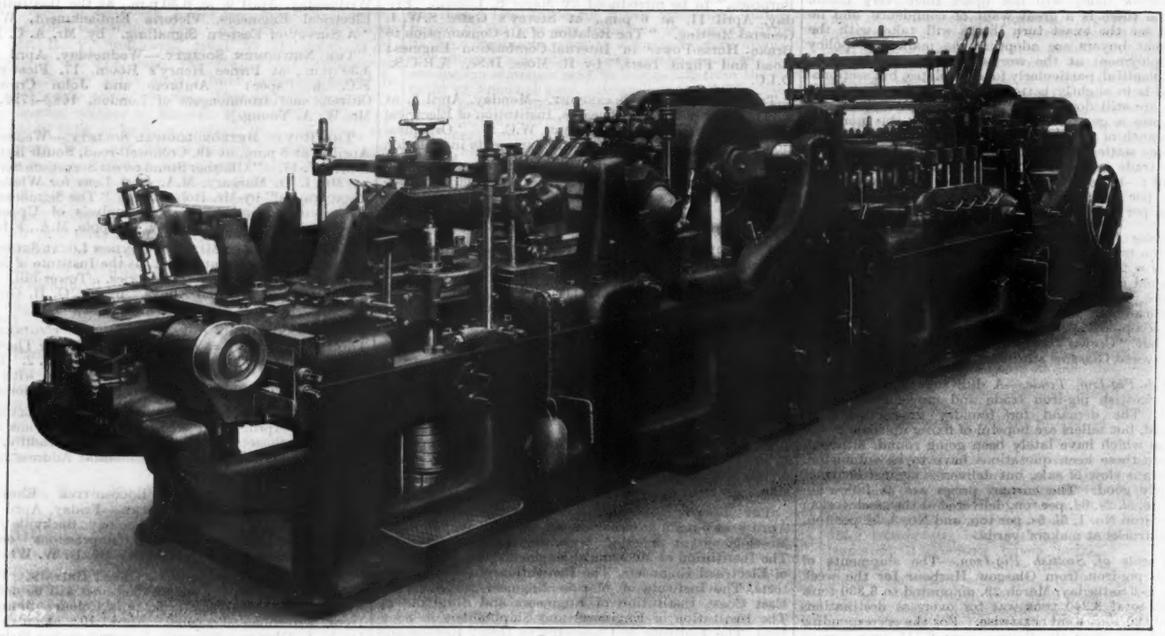


FIG. 1. GENERAL VIEW.

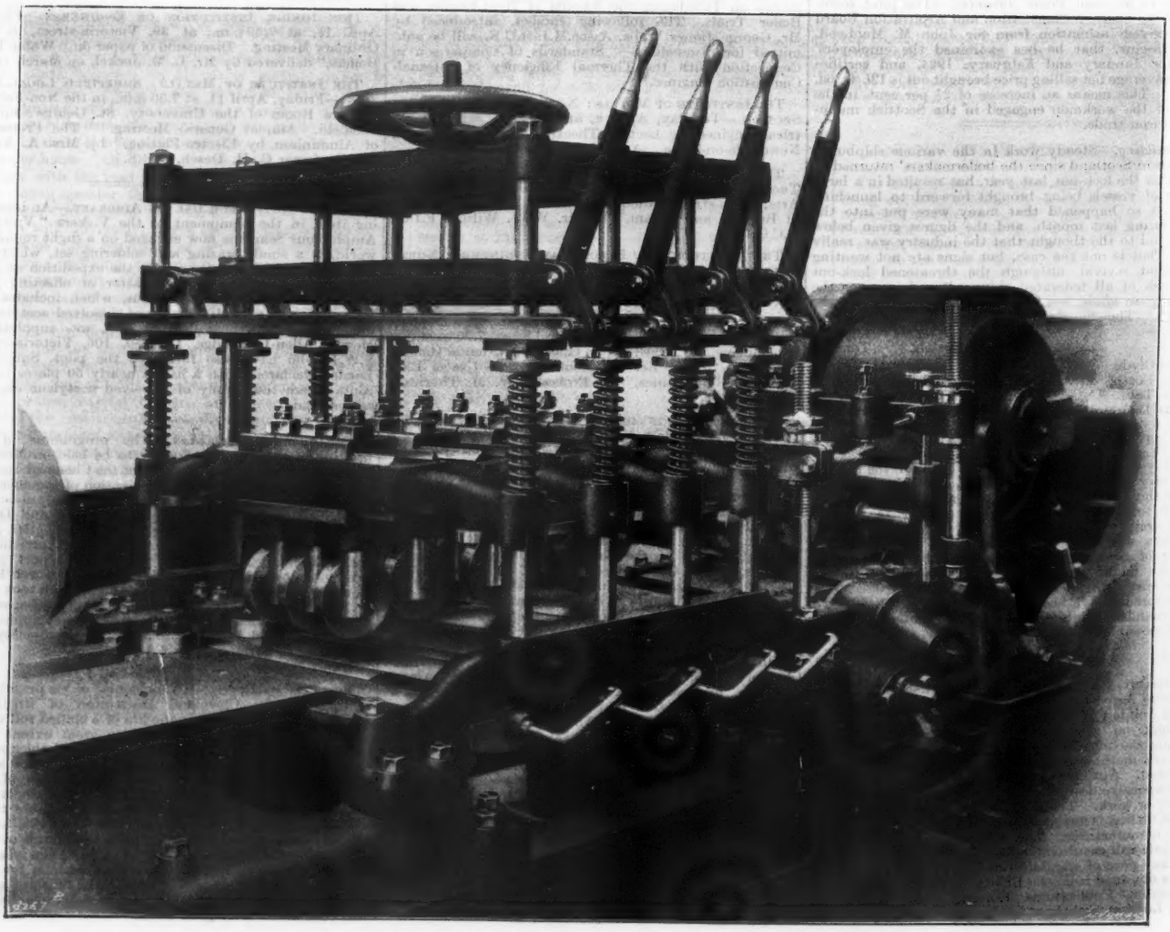


FIG. 2. PRESSURE SYSTEM ABOVE THE FIXED BLADES.

ENGINEERING.

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TIME FOR RECEIPT OF ADVERTISEMENTS.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received 10 days previous to the day of publication.

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ENGINEERING.

FRIDAY, APRIL 4, 1924.

BRITISH MAIN-LINE ELECTRIFICATION.

DESPITE the very considerable amount of electrification work which is being carried out on the London and South Eastern and the South Western Sections of the Southern Railway and in connection with the Underground extensions, electrical engineers in this country incline to a sense of disappointment over the general attitude on the railway electrification question. It is felt that the subject is not receiving the attention it inherently deserves. Sir Philip Dawson spoke for many more than himself when, in the House of Commons on February 27, he pressed that the matter should be advanced by means of the Trade Facilities Act. Sir Philip pointed out the very unfortunate effect which railway grouping had had in connection with the matter. Before the amalgamations it was the definite intention of the London, Brighton and South Coast Railway to complete the conversion of its suburban lines and to electrify its main line to Brighton, while the Great Eastern Railway proposed to electrify the whole of its suburban system, radiating from Liverpool Street, and the North Eastern Railway intended to convert its main line from York to Newcastle. Sir Philip did not mention it in the House of Commons, but there was also a scheme in being for the electrification of the suburban lines of the Caledonian Company in the neighbourhood of Glasgow.

One reason for the delaying effect of the railway grouping on work of this kind is not difficult to surmise. Such a concern as the recently constituted London, Midland and Scottish Railway is probably still sufficiently busy in attempting to bring its constituent members into some sort of unity to wish to complicate conditions at the moment by embarking on extensive schemes which can be postponed. The unification of the staff, of methods of accountancy and of traffic procedure may well be sufficient in themselves to occupy the whole of the time the Board has to spare from routine matters. A further delaying effect is obvious. The fact that the Board of the North Eastern Railway was satisfied that the electrification of the main line from York to Newcastle was desirable is not in itself reason why the Board of the London and North Eastern Railway should be similarly satisfied. Obviously, the incoming directors from other railways required to have the facts and arguments presented to them, and the whole thing has practically to be gone through again *ab initio*.

Although reasons of this kind may be an explanation of the present state of affairs, the reasons do not make the state any the less unsatisfactory, and it is greatly to be hoped that the whole question may receive the attention it demands with little further delay. Sir Philip Dawson, in the speech to which we have referred, pleaded the case of railway electrification from the point of view of the alleviation of unemployment. The point of view is an important one. The claims of the skilled man have not been overlooked in work which has been put in hand with the assistance of public money or credit, but, none the less, there has been a great tendency to concentrate on works more likely to aid unskilled than skilled labour. This is a mistaken policy. A skilled man out of work represents a greater proportion of the productive power of the country idle than does an unskilled man, and he should have the first claim in any schemes which are undertaken to create employment. This point of view does not neglect the interests of the unskilled man, as one of the best ways to get him also into employment is to arrange, as far as possible, that the more valuable producer shall be put into a position to produce. The employment of any skilled worker necessarily carries with it the employment of a greater number of unskilled workers.

While it is necessary that any works undertaken under the Trade Facilities Act should be of a sound nature and likely ultimately to pay their way, it would be difficult to find any sphere of work more promising from this point of view than railway electrification. This is a class of work which, as far as this country is concerned, has not a single failure to record. All conversions have been financially successful. It may, however, be suggested that electrical engineers are less in need of any artificial provision of work than many other classes of workers, since, as Mr. Longbottom pointed out in his address to the British Electrical and Allied Manufacturers' Association on March 20, which was reported in our issue of last week, the percentage of unemployment among insured workers in electrical engineering in January was only 5·9, as compared with 19·1 per cent. in general engineering and 11·8 per cent. in all industries. To use this fact as an argument against utilising the Trade Facilities Act to assist railway electrification would, however, hardly be sound, as this class of development would carry three great advantages—the first lying in the fact that the work would practically certainly be financially successful, and the second in the fact that there are several schemes worked out in detail which could be put into operation with little or no delay. It is also necessary to remember that railway electrification is by no means only an electrical engineering matter, and that a very large proportion of the work which would have to be put in hand would come rather under the heading of mechanical and general engineering. The third great claim which railway conversion can put forward for favourable consideration under the Trade Facilities Act is that it would be almost impossible to find any other type of work of greater public benefit. The improvement and cheapening of our transport facilities would be of enormous value in assisting the general economic recovery of the country.

The case for suburban electrification has been amply made by trial and experience, and it cannot be that any suburban conversions are held up owing to doubts, either technical or commercial, about their practicability. Main line electrification is, however, a somewhat different matter, and although the directors of the North Eastern Railway were evidently convinced that the conversion of the main line from York to Newcastle was a desirable

piece of work, it is not difficult to understand that some of the railway boards may not yet be convinced that main line electrification offers any particular advantages for British conditions. Matters which have become commonplaces in electrical engineering circles are still probably entirely outside the vision of most railway directors, and the present business of the railway electrification enthusiast is in some way or other to bring railway boards and traffic managers to a proper realisation of the advantages which main line conversion offers. Many excellent papers have been read before engineering institutions proving the case for conversion, and their number was added to on the 27th ult., when Lieut.-Colonel H. E. O'Brien read a paper on "The Future of Main-Line Electrification on British Railways" before the Institution of Electrical Engineers; but it is very doubtful if these papers are ever read by the people it is necessary to convince before any great progress can be made.

Mr. Roger Smith pointed out in the discussion on Colonel O'Brien's paper that it is necessary that the traffic people should be brought to the point of view of regarding electrification favourably. At present many of them certainly do not want to be bothered with the matter. Any properly carried out main-line conversion would be of enormous value to them, but as yet they do not see this. All they know is that electrification would involve them in a great deal of work and would force them to change many of their present methods. From the point of view of converting the unconverted, it is doubtful if Colonel O'Brien's paper, admirable although it was, was cast in the right form. As will be seen from the long abstract, which we begin to publish in this issue, he argued the case in general terms. His paper was a valuable contribution to the subject, but we think it would have appealed more strongly to the non-technical traffic man if it had concerned itself with the discussion of a single specific case of main-line electrification. We hardly know if his official position would have prevented him to do so, but if the author had taken an actual example, say of the main line between London and Rugby, and had contrasted the details of present conditions with possible conditions after electrification he might have raised a general interest in the question, which at present does not exist. If the consideration of a specific case of this kind on his own railway is too much to ask from Colonel O'Brien, we would be prepared to accept a definite case put forward without its actual location being specified. We would, however, much prefer an actual specific example to be taken. Such a paper would probably give rise to general public interest, daily newspaper correspondence, and much criticism of the railway company. But that is just what is wanted.

The details of Colonel O'Brien's paper we need not go into here, as they will be found in our abstract, but we trust that in some way his contention—that the electrification of main lines carrying heavy traffic is more urgent and more important than suburban electrification—will be definitely brought to the attention of those who really decide such matters. Before leaving the subject, however, we must express surprise at Colonel O'Brien repeating the old fallacy about the load factor and coal consumption of power stations. We referred to this matter in our first leader last week, in connection with Mr. Patchell's presidential address to the Institution of Mechanical Engineers, and it has been much discussed both in our own columns and elsewhere during recent months. Discussing power stations for railway supply Colonel O'Brien says: "These high load factors will naturally result in low coal consumption." The most convincing evidence, however, that a high load factor will not "naturally" do anything of the kind is to be found in Colonel O'Brien's own Table III, which shows that the lowest coal consumption of actual stations referred to is found in conjunction with practically the worst load factor.

INDUSTRIAL CONDITIONS IN BELGIUM.

IN the introductory statement to a Report on the Economic and Financial Conditions in Belgium, December, 1923, prepared for the Department of Overseas Trade by Mr. J. Picton Bagge, it is said that the improvement in the industrial activity which became noticeable in the year 1922, was fully maintained throughout the whole of 1923. The exact position was best indicated by the unemployment figures. In December, 1922, there were only 4 per cent. of the industrial wage-earners without work, but that condition was improved upon in 1923 and the latest returns available, those for October last, show only 2 per cent. of unemployment. In many industries there was a shortage of labour, and it had been found necessary to import a certain number of foreign workmen. This happy state was due mainly to the large export demand for goods, favoured by the depression of the franc and also to some extent by the elimination of German competition, consequent on the state of chaos which existed in that country.

The improvement in the industrial situation of Belgium was mainly due to the extension of export trade, which may not be a durable condition. Were it due to a real growth of the world demand for goods in which Belgium was reaping more than her normal share through cheap production and the privileges accompanying depreciated currency, it would be a happy augury of real and general improvements to come. It is true that there is an increased world demand for some few classes of goods, but it is more than doubtful if this is generally the case. The Government of Belgium evidently appreciated this, as was indicated by their action, when issuing permits for foreign workers to reside in Belgium, of limiting their duration to short periods. Were the peculiar exchange conditions existing at present to come to an end, many thousands of workmen now migrating to France may eventually return to Belgium. There is a further indication of the prevalent fear that present conditions cannot persist, in the fact that great caution is shown in purchasing by the trading and industrial community. They are not accumulating stocks but merely accepting goods for immediate or short delivery. There is thus an entire absence of speculation and as business is being conducted on a sound basis, industry will be better able to weather the anticipated period of depression when it comes. The Reparations question dominates the whole situation, and there is great instability of economic life due to the state of political uncertainty in Europe.

The budgets for 1923 and 1924 showed a total deficit of four milliards of francs. Taxation, although heavy, did little more than meet the charges for the public debt, service and pensions. The outlook is, therefore, gloomy, but the conditions are by no means peculiar to Belgium, nor is she the most ill-fitted to deal with the situation. The country has rich resources and a people possessing great capacity for work and fertile in initiative. The indomitable will and great power of resistance shown in times of international stress are not being cast aside when dealing with the problems of industry in times of peace. The country possesses a well-organised financial, industrial and commercial machine, the factories are modern and well equipped and the ports and means of communication are highly developed. Immense supplies of coking coal it is anticipated will be available in the future from the Compine basin, of which the development is being undertaken at present.

The watchword which Belgium has adopted is "Import less—Export more—Produce more." The Government encourages and anticipates increased home production of grain and dairy products, which will decrease the necessity for importation and thus assist in reducing the adverse trade balance. Active endeavours to improve overseas trade by the provision of information is undertaken by the Government, and propaganda is being conducted with the same intention. Economic missions have been sent overseas to study markets and to start business relationships, particularly in South America and Japan, while a train exhibition is being sent to tour through Italy. The employers in Belgium have instituted a remarkable scheme under which family allowances, in addition to wages, are paid to those workmen who have children to support. This scheme has been largely extended during the last 18 months and may now be said to form a permanent part of the Belgian social and economic organism.

Although Belgium is to-day enjoying a period of industrial prosperity there are still many dangers ahead. The people who mobilised their forces to deal with the reconstruction problem, which is now steadily approaching its end, were preparing for the future improvement of their overseas trade. Though the prospects of maintaining continuously the present conditions are not bright, the Belgians are steadily working for the future well-being and prosperity of their people.

FOUR-WHEEL BRAKES FOR MOTOR-CARS.

ACCELERATION, positive and negative, has become as important a question in road transport vehicles as in the case of railway rolling-stock. In the latter instance the proposal to apply brakes to all the wheels on passenger trains was at first regarded with disfavour by some locomotive superintendents; in fact, as then stated by one of them, the trouble and expense involved in turning up the wheels of the tenders and brake vans was already heavy and would be greatly increased if the whole of the wheels of a train had to be so treated. Although the requirements of fast passenger traffic have overruled this opinion, goods trains in this country are still dependent on the earlier method of braking. Acceleration on railways, when positive, seldom exceeds 2 ft. per second^2 and the local train that can attain a speed of 30 miles per hour in 30 seconds only requires a constant acceleration of about 1·5 ft. per second^2 to attain this result; the negative acceleration for stopping, however, may frequently reach a maximum of 4 ft. per second^2 and occasionally may attain 5 ft. per second.^{2}

The case of the motor-car is different because, being driven by sight instead of to signals, the accelerations have become very much greater; in fact, accelerometer diagrams obtained by Dr. F. W. Lanchester in 1910* showed maxima exceeding 11 ft. per second^2, and the figures quoted by Mr. Acres, in a paper on four-wheel braking systems† for observed stopping distances at speeds over 20 miles an hour with rear brakes only, give equivalent constant accelerations ranging from 7 ft. to 9 ft. per second^2, and therefore probably attaining maxima exceeding 11 ft. per second^2. Dr. Lanchester pointed out‡ that the couple set up by accelerative forces gives rise to a change in weight distribution, and even causes appreciable changes of trim in lightly-sprung vehicles. Since 1910 the tendency to increase the wheel-base, to lower the centre of gravity and to arrange a more recumbent position for the driver and the passengers has facilitated increase in the negative acceleration due to braking. Actually further analysis of the figures observed in stopping tests (quoted by Mr. Acres) shows that the vehicles fitted with four-wheel brakes gave, at speeds of 40 miles to 60 miles per hour, equivalent constant accelerations of 17 ft. to 28 ft. per second^2 and give maxima that exceed that due to gravity. This, of course, could not be obtained without a very high coefficient of friction between the tyre and the road, and to what extent improvements in tyre construction have been a factor may be judged from the calculated coefficients of friction which in some cases are equal to, or even slightly exceed, unity. It would be far-fetched to suggest fitting sliding seats, so that the mass of the driver should itself act on the brake pedal, or pedals and levers, and thus eliminate the servo-gear with which the more elaborate four-wheel brake systems are described as being fitted, but, with accelerations of such magnitude, the force exerted would be nearly equal to that applied by standing on the pedals.

The arrangements made for taking the torque due to the drive of the back axle are such as to serve also for taking the torque due to the reverse gear, and consequently they may be taken as adequate to the braking effort in both directions, but the existing

* Proceedings of the Inst. of Automobile Engineers' Vol. IV., page 123 *et seq.*

† Some Notes on Four-wheel Braking Systems. Paper read before the Inst. of Automobile Engineers (North of England Centre, in Manchester), on March 25, 1924.

‡ *Loc. cit.*, p. 136.

arrangement of the front axle is unsatisfactory for the following reasons: (*a*) the centre of the area of contact of the tyre and the road is usually several inches from the point at which the axis of the stub-axle pivot meets the ground, and the distance between these points forms the arm of a couple balanced approximately by that produced by the other front wheel; the relative magnitude of the couples varies constantly and their joint effect is to subject the steering connections to heavy stress; (*b*) the torque must be transferred to the frame through the top leaf of the spring and its anchorage, usually at the front end, so that the stress is greatly increased as also is the risk of the axle moving back should fracture of the top plate occur in front of the axle; (*c*) in rounding a curve, and it is often necessary to steer in emergency, there is change of weight distribution laterally and, considering the high coefficients of friction, this involves the possible locking of the inner wheels; consequently, it is desirable that the distribution of braking effort should be so controlled as to transfer a portion of the total to the outer wheels when steering; (*d*) the anchorage of the back springs is usually in front of the axle; depression of the car body and flattening of the spring causes increased application of the brake, but with the front-wheel brake and the usual anchorage the reverse occurs, because the flattening of the spring reduces the pull on the rodding unless (as in an example quoted by Mr. Acres) the design is so modified as to bring the attachment of the rodding in front of the brake arm. In any case it is necessary that the front springs should be made of sufficient strength to carry the increased loads to which they are subjected by the maximum brake effort and by the combined longitudinal and transverse changes in weight distribution. It has also been pointed out that the fundamental requisites for front-brake design are: (i) the arrangement of the connection between the operating rods so as to come on the centre line of the steering pivot; and (ii) the combination of this with "centrally-pivoted steering," essentials that were laid down by P. L. Renouf in 1904. These features are already observed in well-designed front-wheel brakes.

The adoption of four-wheel brakes with a view to reduction in the stopping distance leads to an inquiry into the relative advantages and disadvantages of the front and back-wheel brakes. It is well known that, except under abnormal conditions, it is possible with skill to neutralise the side slip arising from skid caused by back-wheel brakes, and to prevent the vehicle turning through 180 degrees; it is not, however, possible to neutralise the front-wheel skid that causes the vehicle to continue in a straight path unless an external influence, such as road camber, should cause deviation; all that can be done is to take off the front brake and apply the back brake as hard as the conditions will permit. By this method a car that is on a surface so greasy that it will not answer the steering wheel may be caused to obtain sufficient hold to respond to the steering wheel. The arguments may, therefore, be summed up in the following conclusions, which take into consideration the Regulations (use and construction of motor-cars) which require that "the motor-car shall have two independent brakes . . . of such efficiency that the application of either to the motor-car shall cause two of its wheels on the same axle to be so held that the wheels shall be effectually prevented from revolving or shall have the same effect in stopping the motor-car as if such wheels were so held." Adopting the terms "service" and "emergency" respectively for the brakes used most frequently and those operated as an auxiliary, the arguments based on past experience and habit point to the adoption of the rear-wheel brake for service and indicate that the emergency brake should either be solely a front-wheel brake or should be a combined four-wheel brake. The natural movement to which the motor-car driver is accustomed is the transfer of the pressure of his right foot from accelerator to brake pedal, the brake in question being the service brake. On many cars, however, this is a transmission brake and, consequently, useless for holding the car when the driver dismounts, and even if a "slotted" hand lever were added the action of the differential would prevent it from holding the car when one back wheel is jacked up for change o tyre or of spare wheel. The foot brake or service brake should, therefore, be applied to the back wheels and the front wheels should be braked either independently or semi-independently with the back wheels or as a coupled brake acting on all four wheels.

One of the most interesting features of Mr. Acre's paper is his treatment of the subject of brake chatter or shudder, and the discussion of its cure by making the brake definitely cumulative in action up to a fixed ratio to initial pressure. Many cumulative brakes have been produced in the past, of which the "*frein Lemoine*"—consisting of a series of blocks encircled by a cable—with which all premotor public service vehicles in Paris were fitted, was a good example. In many cars chatter occurs in one brake or the other, either forward or backward, or in the clutch when driving the car in reverse; the cure for these troubles has often been difficult to find or to apply, and it is important that provision against their occurrence should be made at the earliest possible moment, when the car is being designed. A similar trouble against which provision should be made is that of front-wheel wobble or castor action, for the prevention of which the author recommends that the axis of the pivot pin should meet the ground about half an inch on the inside from the centre of the area of contact of the tyre with the ground, thus affording a steady drag and preventing the rapid vibration and hammering permitted by the play in the pin-joints of the steering connections.

The question of the safety of four-wheel brakes to the vehicle itself and to others is open to little doubt; the horse-drawn vehicle with brakes either completely absent or rudimentary is one extreme, and the electric tramcar fitted with magnetic brakes of unlimited fierceness is the other. Both of these types of vehicle can be recognised and due allowance made for their peculiarities, yet it is possible for a car fitted with ordinary rear-wheel brakes to be damaged by the shafts of a following horse-drawn vehicle when an emergency stop has to be made very soon after the release of a traffic block. The risk of this type of collision will be much greater at the commencement of the introduction of four-wheel brakes when only a few hundred vehicles are so fitted and half a million motor-cars require a distance from 50 to 100 per cent. greater in which to come to a stop, and the drivers of the existing cars may demand that some distinctive mark should be carried on four-wheel-brake cars as a warning against following such vehicles too closely.

THE INSTITUTION OF MECHANICAL ENGINEERS.

An extra general meeting of the above Institution was held at 6 p.m. on Friday last, the 28th instant, at Storey's Gate, Westminster, the chair being occupied, in the absence of the President, by Mr. William Reavell, Vice-President.

Standard Tests for Hydraulic Power Plant.

The subject for discussion at the meeting was the report on "Standard Tests for Hydraulic Plant," drawn up by the Joint Committee of the Institutions of Civil and Mechanical Engineers. This report, though the fact was not mentioned in the copies prepared for the meeting, was, it was explained, of a tentative nature, advanced to secure comment in the light of which the final form might be prepared. The report was divided into eight sections, of which the last consisted mainly of two large tables for suggested test sheets. An appendix was also added. The first section was introductory, setting out the object of tests and stating that these might be conducted in connection with guaranteed performance, or with a view to improvement of design. The second section was devoted to definitions; the third to sub-divisions of plant, the installation being so sectionalised that serious losses might be definitely located. The measurements necessary were dealt with in section 4, while in the following section the methods of making these were dealt with. Operating conditions and duration of tests were the subject of succeeding parts of the report, while, as already noted, the eighth section took the form of suggested test sheets. The appendix dealt with apparatus for measuring the volume of flow of water, and detailed what, in the impossibility of the use of a measuring basin, might be regarded as the most suitable alternatives. These comprised the Venturi tube method, the Pitot tube, weirs, current meters, floats, and the salt solution method. In each case suggested procedure was put forward, with in some instances diagrams showing approved arrangements. In connection with the salt solution method two sketches showing arrangements for procuring uniformity of rate of dosage were given, while the lay-out recommended in the Turbine Test Code of the American Society of Mechanical Engineers was also reproduced.

The Chairman, in opening the meeting, said that the report was the outcome of the work of a joint committee of the two Institutions. It was not final, and the meeting had been called to consider it and offer criticisms and suggestions; this would assist the committee in drawing up the final code. He thought discussion of such codes in their embryonic stages was the best way of ensuring that, when complete, they would fulfil the objects for which they had been prepared

Professor A. H. Gibson, in making a few introductory remarks, said there was no great utilisation of water power in this country, but in our overseas dominions extensive developments were taking place or expected. Moreover, the guarantee of performance required by the purchaser from the manufacturer was assuming considerable importance, and standard tests were, therefore, becoming necessary. Any suggestions for improvement in the report submitted would be welcome. The committee desired to express their thanks to the many firms of turbine makers consulted, for numerous valuable suggestions.

Professor S. M. Dixon urged the advantages of a full discussion. Before finally deciding upon a code which would be in force for even a few years, it was necessary that it should be approved by the manufacturers concerned. The efficiencies which the code was devised to test should not prove inferior to the efficiencies as measured by competitors. The essential point was to ascertain how the quantities should be measured in order to give the best results, and what formulæ should really be adopted for measuring quantities by any particular means.

Professor F. C. Lea felt that not only should the code be helpful to sellers and buyers in a general way, but it should aid them to examine their plants more critically. He had lately been doing some work in relation to a large weir, with a 15 in. to 18 in. head and a length of over 20 ft. This had clearly illustrated the necessity for care. It had been possible in this case to measure the quantity of water in a straight channel, and also where it was mixed up thoroughly after passing over the weir; for the latter the salt solution method had been suitable. In the straight channel he had used an ordinary current meter, carefully calibrated. For checking the flow at the weir he had adopted a formula supposed to be accurate, which, personally, he suspected to be wrong, because of the shape of the weir, which had a depressed instead of a free nappe. The quantity measured by the current meter in the straight channel, where the flow was steady, and by the salt solution method, where the water was disturbed, agreed very well, but differed largely from the results which the weir was supposed to give. With regard to definitions, the report contained one or two definitions which were not in agreement with the American code, but they related only to small details.

Major W. H. Munro, who spoke next, remarked upon the fact that the report contained both a set of rules by which turbines were to be tested and rules for guidance in improving various parts of a hydraulic plant. In the third place, instructions were given. He did not regard rules as a first essential in the field of research; rather, ingenuity and experience. The rules should be couched in language which was clear to the engineer, and it would help matters if no question as to the interpretation of such rules could exist. The Committee should separate in the report matters dealing with research from those which were related to referee questions. The Americans, Swiss and Scandinavians knew a great deal about water turbines, and their propaganda was in opposition

to the building of turbines in England, warnings being given of the limited experience of this country in such things. If the Americans found it possible to pick holes in rules drawn up here, he thought a great deal of damage to this country would result. The set of rules applied to steam, which were developed here, undoubtedly represented the highest standard, steam being thoroughly understood in this country; but he would emphasise the danger of adopting any set of rules which were not either equal to or better than others existing abroad. He thought the Gibson rules, relating to flow and flow standards, which were now almost entirely used by the Ontario Power Commission, should be included amongst those referred to as "approved" methods. He found certain things unnecessary. Among definitions in the report, for instance, there were too many definitions of "head." For testing a turbine it did not matter, in the case of a Pelton wheel, whether the tail race was 10 ft. or 50 ft.; the essential point was the head that was being used, and the manufacturer would base his definition on that.

Mr. J. L. Hodgson referred to the statement in the report that the coefficient of the Venturi tube "may be taken as $0{\cdot}99 \pm 0{\cdot}01$ under normal conditions of operation." In Fig. 1 he had plotted practically all the tests that had been published on Venturi tubes. It would seem that the statement above referred to only applied to the "Kent" Venturi tube, and only for that tube for values of R which were greater than 100. For instance, the value of the coefficient for a "Simplex" Venturi tube when R was 100 was about 0·94. Special research had been undertaken by Messrs. Kent during the past 14 years to obtain a level coefficient over as large a working range as possible.

He disagreed from the statment that the coefficient of a Venturi tube was apt to "vary somewhat irregularly" at velocities less than 1 ft. per second. If one assumed that the velocity in the throat was ten times that in the main, and that for a well designed Venturi tube the coefficient did not begin to fall steeply until the value of R had fallen below 50, it could easily be calculated that the level coefficient could be maintained down to velocities in the main of 0·316 ft. per second for a 1 in. tube; 0·063 ft. per second for a 5 in. tube; 0·0063 ft. per second for a 50 in. tube; and 0·00325 ft. per second for a 100-in. tube. It would also be seen that for values of R below 50 the variation of the coefficient was not irregular, but definitely followed the viscous instead of the square law.

If one attempted to generalize in hydraulic problems on the simple basis of velocity it almost inevitably led to confusion. The correct basis for such generalization was the Reynold's criterion R. He trusted that this criterion would be introduced into the report, as a knowledge of it was becoming increasingly important for hydraulic engineers. The simple Pitometer shown in Fig. 2 was preferable to that referred to in the report. This Pitometer, whose tip consisted of a simple cylinder bored with upstream and downstream holes at opposite ends of a diameter, was cheap to make and easy to reproduce with accuracy. It also gave a constant coefficient in water over the range of velocities which were usually worked with.

The report included no simple and accurate method of determining the discharge through closed circular conduits. The square-edged orifice, which he had been the first to introduce for air, steam, gas and water measurement some 14 years ago provided such a simple and accurate method. The necessary data were given in Fig. 3. The orifice should be installed two-thirds of the way down a 15 diameter length of parallel piping. The values of the coefficient of discharge given in Fig. 3 would be found to be accurate to within ¼ per cent. for values of a_2/a_1 up to 0·5, and to within ½ per cent. for values of a_2/a_1 between 0·5 and 0·7. It was inadvisable to use orifices for which the value of a_2/a_1 was greater than 0·7 owing to the difficulty of centring them accurately, and the great importance of measuring the upstream and downstream diameters correctly, and the necessity for obtaining a standard distribution of the streamlines across the section. All these points were of minor importance when a_2/a_1 was small. That such a plate orifice could be used without causing undue loss of head was shown by the following table, which was calculated out on the basis that a_2/a_1 for the orifice was 0·7 and that the head lost was 46 per cent. of the head produced.

Velocity in main in ft./sec.	Head produced in inches of water.	Head lost in inches of water.
4	7·57	3·5
6	17·0	7·8
8	30·3	14·0
10	47·4	21·8

If Venturi tubes had been used the same "heads produced" could be obtained at one-third or one-quarter of the tabulated "heads lost."

Mr. Hodgson also suggested that the report might be improved by the inclusion of further details of measuring instruments and their manipulation. In particular he pointed out that the Single Tube Manometer in which practically all the change of level occurred in one limb was preferable to the ordinary U-gauge, where two limbs had to be read simultaneously.

The values of the symbols used were given under Fig. 3, with the exception:—

ζ = coefficient of friction. (P_1-P_2) = drop of press. in lbs./sq. ft.
$g = 32{\cdot}2$.
D = diameter in feet. V = velocity in ft./sec.
L = Length in feet.

Mr. J. H. Armfield, who followed, suggested that records of actual tests set out in standard form would have extremely valuable results, by making available data of installations under stated conditions. Members of the two Institutions should be urged to file with the Institutions copies of all completed test sheets. He wished to draw attention to a type of installation or setting used for some while on the Continent and, in this country, by his own firm, with great advantage for low heads; namely, the raised head chamber, or raised turbine flume. Properly, such an arrangement should be considered as an encased setting, but the essential point was that the cover of the casing was above head water level. The primary object was to reduce the depth of excavation by enabling the turbine to be used at a level at which it would certainly draw air but for the cover. The elevation of the cover above head water, the submergence of the seal, and the submergence or elevation of the highest point of entrance of the turbine-guide ring in connection with the draft tube should, therefore, be recorded. If, in the case of a raised turbine or raised draft tube, external means of exhausting the air were used, this fact should be recorded. In the case of an open turbine setting the form, whether rectangular, circular or spiral, might be recorded, and for both turbine setting and draft tube the material should be specifically mentioned. The number of buckets and guide vanes in connection with the turbine would be a matter of interest, while the effect of this upon the efficiency of the turbine was a matter on which more exact information would be very desirable.

Fig. 1. $Q = \Omega A_1 A_2 \sqrt{2gh/(A_1^2 - A_2^2)}$. $\zeta = gD(P_1-P_2)/2V^2WL$.

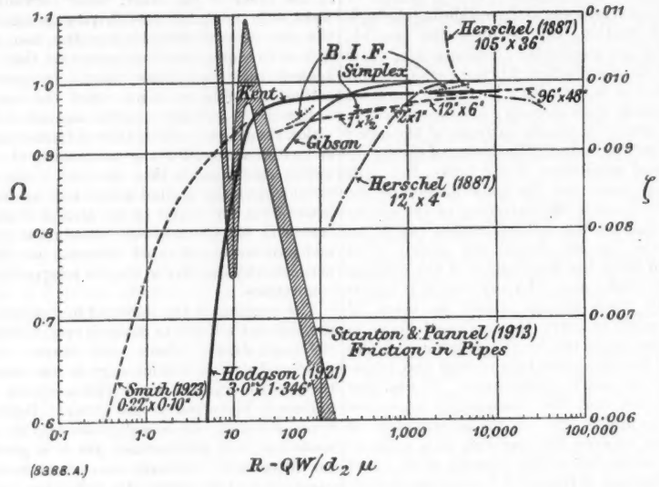


Fig. 2. PITOT TUBE WITH CYLINDRICAL TIP.

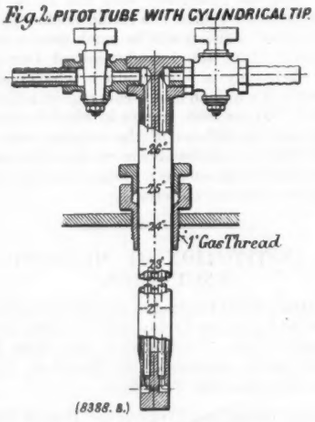
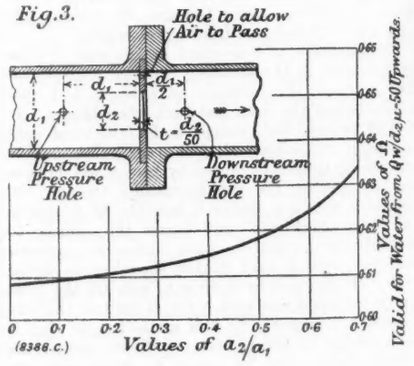


Fig. 3.


Hole to allow Air to Pass
Upstream Pressure Hole
Downstream Pressure Hole
Values of a₂/a₁
Values of Ω Valid for Water From Qw/d₂μ = 50 Upwards.
(8388.C.)

$$Q = \Omega \frac{a_1}{\sqrt{n^2 - 1}} K \sqrt{\frac{h}{W}}$$

Q = Flow in cusecs.
Ω = Coefficient of discharge.
a_1 = Area of pipe in square inches.
a_2 = Combined area of orifice and small hole above orifice in square inches.
$n = a_1/a_2$.
K = 0·1270.
h = Head in inches of water weighing 0·03604 pounds per square inch.
W = Density of fluid passing in pounds per cubic foot.
d_2 = Diameter in inches.
μ = Viscosity in C.G.S. units.

With regard to the governor, the possibility of using an electric relay should be provided for. Referring to Table II of the report, the specific capacity of the turbine was an item of interest; he would define this as the capacity of a turbine of unit diameter under unit head at the rated speed. The pressure on both head and tail sides of the turbine—in connection with governing tests—should be noted. Under "auxiliary equipment" particulars should be given of the device known as the "head intensifier," an arrangement by which water from the head was injected through the draft tube, thereby increasing the effective head on the turbine. It was essential in measuring water that the method used should not check the flow or vary the effective head under which the turbine was working.

Mr. H. D. Cook said it was difficult to interest purchasers sufficiently in efficiency to cause them to take real tests. For that reason the rules should be simple and the apparatus simple and cheap. Most of the methods mentioned in the report failed under commercial conditions. The Venturi meter was expensive and resulted in lost energy. The Pitot tube again did not seem very reliable unless elaborate traverses were made. The Gibson method already mentioned, and the Allen salt method should be included in the report. In the latter each little particle of salt became virtually a float, and, by measuring the passage of the resulting kick of the current between two pairs of electrodes placed at intervals down the pipe-line, a very simple and direct reading was obtained of the velocity of the water flowing. The method had the merit of being cheap as well as applicable to large installations. With this simple system it was not even necessary to have a closed pipe of uniform section.

Mr. H. S. Rooke referred to the method of measuring flow by means of the calibrated sluice. A tank was fitted at the station. The water level in the tank was kept constant by means of a sluice gate, a certain amount of opening of this sluice gate corresponding to a certain discharge. The method was in use in several works stations. There were certain types of plant for which it seemed almost impossible to find a reliable form of test; as, for instance, such plants as those at Chester and York. In the case of York it would probably be necessary to construct side walls in the tail race so that the water from one turbine could be localised. The need for a channel was due to the absence of any tail race; the turbines discharged straight into the river. In the case of such plants, where expensive tests would not be justified, the efficiency obtained from test models would have to suffice. Referring to Table I in the report, "No. 30, Net Rack Area," did this relate to the sum of the submerged areas between the bars, taken in the direction of flow, or did it refer to the submerged area in which the rack was placed? If the latter, the width of the bars should be included. In Table II, the runaway test was not included, though a runaway test of five minutes was sometimes insisted upon. With regard to item "(31), Governing Tests—Time to Change Load (secs.)," was that the time taken by the governor to move the gates, or did it refer to the time occupied in taking the load off or putting it on? In tests of pipe-lines, it would seem important to include the effect of the governor action on the pipes and pressure rise.

Mr. E. R. Howland said Pitometers, in many cases, were made to template and calibrated by the coefficient of standard construction as known. With the Pitometer higher differential pressures were obtained than with the Pitot tube, a very important point when dealing with low velocities. With regard to the statement that the coefficient of the Pitot tube was higher in still water ratings than in a current, his experience showed that instruments tested under both conditions had given identical coefficients. As to the use of the Venturi meter in hydro-electric systems, he would say that the loss of head was negligible in the case of high heads; with low heads it became a matter of importance. In one case he knew of, a penalty of £50 per inch for additional loss of head was imposed.

Mr. R. A. Ryves thought that any established code, whether generally followed or not, at least afforded a means of obtaining a clear idea of the capabilities and performances of any plant. There were certain possibilities as between different heads; if the full head were not being used, full justice might not be done to the plant. He agreed that the code part of the report should be separated from the research part.

With regard to the flow of water in an open channel of considerable size, much might be done by constructing a portion of the channel in a very distinct shape. A perfectly rectangular channel would probably be well adapted to measurement by float. One difficulty in measuring the flow of water in an open channel arose with changes of resistance in the device used, such as a weir. A reduction of resistance due to slime, for instance, would increase the flow. That must be regarded as applying to the surface of the sill of the weir, the sides, and so on. Owing to the difficulty in getting correct formulæ, efforts should be made in two directions, one to do away with the contraction effect and the question of the nappe by constructing a weir over which the water would flow with entire smoothness. The stillness of surface produced by rounding the ends and rounding the sill—by the curved tail apron—would probably lead to more accurate results. His other suggestion was to have two weirs, one above the other, interposing a wall between them pierced by holes, and to measure the difference—in both cases in still water—between the water level up stream of the dividing wall and the water level below. The practical way of measuring water-flow would, he thought, be in the direction of the submerged weir with perfectly smooth approaches, and also the two-weir system with a dividing wall having perforations.

Mr. Eric Crewdson, remarked, in relation to the formula $V = C\sqrt{mi}$, that he would like to have a table of values for C for various roughnesses, or else a reference to some original paper embodying these coefficients. A bibliography at the end of the report would be useful. Personally, he would cut out from the code the reference to floats, which were not satisfactory. He was in favour of including the Allen salt velocity method for use in closed conduits. He had himself made one direct comparison in the case of a reservoir of rectangular dimensions, by which he had checked the measurements by the salt velocity method, and found the results very close. In the report, he would be glad to know the difference between "Elevation of surface of full pond"—No. (8)—in Table I, and "Elevation of Crest of Spillway"—No. (13). With regard to No. (54) (*c*), in the same table, "Submergence of highest point of entrance to guide ring," mention should be made of the discharge at which the submergence was measured. It would meet the case to add "full discharge." What, again, was meant by "Discharge area of runner," (62). Possibly, it meant the circular area corresponding to (61)," "Maximum discharge diameter of runner." It might, however, mean the sum of the discharge areas at the exit from the turbine vanes. With regard to "Governing Tests," (31) of Table II, something should be added to "Instantaneous Fluctuation of Speed." In plants with several units working in parallel, it was usual to allow a difference of, say, 3 per cent. between light load speed and full-load speed of a turbine. Did the definition mean, therefore, instantaneous rise or the load thrown off? No rules were given in the report as to the instruments to be used and their calibration. He would suggest the following additional rule:—Bourdon pressure gauges and electrical measuring instruments should be calibrated against standard instruments, both immediately before and after the tests, the mean of these calibrations being used if working out the results. If the two calibrations of any instrument differed by more than 2 per cent. at any point the records obtained with that instrument should be disregarded and, if necessary, a new set of tests run.

Dr. A. M. Hogan remarked that kinetic head was defined in the code as $V^2 \div 2g$ ft. A definite numerical value of g should not be given, but the appropriate figure applied according to the locality of the test. The report stated that under favourable conditions, and where carefully used, the discharge over a suitable weir might be estimated with an accuracy of the order of 1 per cent., and the adoption of a sharp-edged "suppressed weir" was advised. Also, the formula to be used was given as $Q = Cl\,h^{\frac{3}{2}}$ cub. ft. per second. This appeared to be based on the experiments of Bazin. Bazin's formula gave more water for a given head than any other commonly used formula for calculating flow over sharp-edged weirs. There was evidence to show that Bazin's formula might not be correct at low heads. In his experiments there was no provision for stilling the water up stream, and oscillations resulted. The surface level was measured by float with a cord running over a cylinder. The effect of oscillation was most pronounced at low heads, and the variation would be a high percentage of the total. A formula used in Scandinavia and other Continental stations was that of Rehpock. In comparison, this formula gave less water than Bazin's. Rehpock's experiments could not, however, be applied to any weir used in practice. His model weir was made of a steel plate set up between plate glass walls. Below 1 ft. head the committee might, until further investigations had been carried out, regard Bazin's formula as better than any other.

Mr. Percy Pitman said the monetary aspect of the matter had been touched upon, and was, of course, very important. In a case in North Wales, the installation being on a Pelton wheel of 1,450 h.p., although the plant and pipe line and reservoir probably cost over a million sterling, no allowance was made for measuring the water, and it was left to the manufacturer to prove that he was giving the efficiency required. The Pelton wheel was 11 years old, and had to be fitted with new buckets. The small allowance of expenditure of 4 per cent. to the electrical engineer was a difficulty, but he obtained from Professor Eckart, of San Francisco, a Pitot tube, which was fitted and proved that the efficiency was up to the guarantee. The Pitot tube method of measuring was very difficult in the case of high-pressure plant. With high heads and small units the engineer was greatly cramped for room. In the foreign plants, with 10,000 h.p. or 15,000 h.p. to a single unit, there was any amount of elbow room.

Dr. Gibson then stated briefly, in reply, that the term "net rack area" was really intended to represent the net water way through the area. With regard to the meaning of the words, "Discharge area of runner," No. (62) of Table I, Professor Gibson admitted that the phrase was indefinite, but it was meant to refer to the actual area of the waterway available for discharge.

The Secretary then read the announcements of forthcoming meetings, stating that there would be an informal meeting to-night, at 7 p.m., for the discussion of "Mechanical Methods of Boiler Firing" and "Rational Design of Mechanical Draught for Combustion Purposes," introduced by Major S. Utting. A general meeting would be held on Friday, April 11, at 6 p.m., when a paper on "The Relation of Air Consumption to Brake Horse-power in Internal-Combustion Engines" would be read by Dr. H. Moss, of the Air Ministry Laboratory.

NOTES.

THE INDIAN INSTITUTION OF ENGINEERS.

THE fourth annual general meeting of the Institution of Engineers (India) was held in Calcutta on February 4 and 5, under the chairmanship of the President, Mr. C. D. Hindley, M.A., Chief Commissioner of Railways in India. In his address the President laid stress upon the desirability of maintaining the standard of the Institution at as high a level as was reached in other countries. The institution rightly demanded before admission a full measure of practical training and practical experience, as well as a further period of practical execution of important works. He hoped it would be possible to enlist the active co-operation of the engineering colleges in the matter of standardising the educational qualifications. At a speech at the dinner, H.E. the Governor of Bengal, Lord Lytton, paid a tribute to the engineering profession, and expressed his pleasure at the fact that the institution had taken steps to establish examinations and recognised courses of practical training, so as to ensure a high standard, of value equal to those recognised elsewhere. He also announced that the Govern-

ment of Bengal had decided to take up the construction of the new Howra Bridge and had prepared a Bill to be submitted shortly to the Legislative Council. The construction of the Grand Trunk Canal would also be proceeded with. Government was also paying attention to the silting up of the Bidyahari River. Sir Rajendranath Mukerjee said that as the Institution progressed it was hoped that it would have a home of its own and build up a substantial permanent fund. Steps would later be taken to secure a charter for it. The number of names on the roll was 678.

KINETIC ELUTRIATION.

In elutriation, which is the hydraulic classification of small particles of different sizes of the same or different materials, water or some other fluid is made to rise through a layer of the material in order to carry up the lighter or smaller particles which afterwards flow off or settle at different rates, the heaviest particles being left behind The rate of settlement depends, according to Stokes, on the size (the square of the radius) and density of the particle and on the density and viscosity of the fluid. But there are other determining factors. Very fine powders strictly follow Stokes' law; particles larger than 0·2 mm. induce eddy currents after attaining a critical speed and then continue to sink at a constant rate, instead of an increasing rate. The wetting power of the liquid, the shape of the particle—whether round or sharp-cornered, offering many points of contact with other particles, whether massive or of needle or plate-form—slight solubility, and the temperatures are all factors of importance, even in undisturbed liquids, and it is hardly possible to predict how a heterogeneous powder would behave when simply allowed to sink. Discussing these problems in a paper on "Kinetic Elutriation," read before the Chemical Engineering Group of the Society of Chemical Industry last Friday, Mr. Leonard Andrews, M.Inst.C.E., M.I.E.E., pointed out that a spoonful of dry sand particles varying in diameter from 0·3 mm. down to 0·005 mm.—introduced beneath the surface of the water to prevent initial floating of the fine dust—would sink in bulk, without separating, with a velocity greater than one would expect for the heaviest particles. The effect was the same when the sand was moistened before immersion, and the same explanation would obviously not fit the two cases. When, however, the heavy particles were first sifted out, the powder would not "flocculate," but break up into a shower of individuals sinking at different rates. In order to avoid this flocculation, "kinetic elutriation" was applied by imparting an initial velocity to the particles. In centrifugal apparatus the containing vessel was rotated; in kinetic elutriation water was admitted under pressure through a nozzle, into the particles in a standing vessel. Mr. Andrews described a somewhat elaborate apparatus for this purpose. The water was supplied intermittently through an automatic valve and a multi-stage ejector into an annular vortex chamber. The opening of this valve and the centrifugal circulation in the vortex chamber produced level changes in the levels of the feed hopper, floating tank and overflow delivery pipe. Heavier particles would be discharged more readily from the vortex chamber than lighter particles; the relation between the static and the kinetic head could be varied by raising or lowering the overflow-tank, and an electric feeler-switch, stopped by a sand seal, prevented an undesirable inrush of water. Mr. Andrews recommended his elutriator, of which several would be used if classification into more than two grades were desired, for ore grading, coal washing, sewage treatment, clay purification and other purposes.

LITERATURE.

History of the Great War, based on Official Documents. By direction of the Historical Section of the Committee of Imperial Defence. *Sea Borne Trade. Vol. III. The Period of Unrestricted Submarine Warfare.* By C. Ernest Fayle. London: John Murray. [Price 21*s.* net.]

MR. FAYLE'S history is a detailed answer to questions of the first importance: how did the sources of our national existence, our shipping, our credit and our industries stand the test of war, and to what tests were they put? His third volume opens on the eve of unrestricted submarine warfare. Both groups of belligerents were then showing signs of exhaustion. The difficulties of the Central Powers have been elaborately examined by German writers: the exact nature of our own have never been fully explained. Mr. Fayle makes it perfectly clear that the root of all our difficulties was a lack of sufficient "carrying power for commercial purposes." Before the submarine campaign began, our tonnage had been absorbed to military uses on a scale for which we had made no provision. We could have met the needs of our overseas expeditions, heavy though they were; but the calls of our allies for British tonnage, to carry their essential supplies, were as insistent as their calls for armies and men. In 1914, our exports to France, Italy and Russia were roughly equal to our exports to other countries; in 1917 they were roughly three times as great. The scale of our recruiting made it quite impossible for us to meet the drain upon our tonnage by intensive building, and in December, 1916, when Mr. Fayle's book opens, we were in the throes of a shipping crisis.

The Ministry of Shipping was formed to meet it; but its difficulties were great. The situation which it had to face was the outcome of economic laws, against which the edicts of a ministry are powerless. "To any general scheme of freight limitation there were two obvious objections. In the first place, shipping was an international business. Every attempt to limit the profits of neutral shipping was inevitably followed by an exodus from allied and neutral trade . . . If British ships were carrying cargoes at artificially lowered rates, neutral shipping would as surely be driven away into trades where there was no such artificial competition." Unrestricted submarine warfare was thus started at a moment when its chances of success were in their zenith; our carrying power was already insufficient, our shipbuilding returns for January, 1917, showed a steady, continuous, decline, and our allies were by then as dependent as ourselves upon those seaborne supplies against which the blow was directed.

Mr. Fayle brings out the effects of the new campaign with force. The German submarine commanders succeeded almost at once in doubling the rate at which shipping was being destroyed. During the quarter before the submarine campaign began, shipping losses had averaged 344,000 tons per month, of which 168,000 had been British; in February, the first month of the new campaign, these figures were raised to 594,000 and 313,000 respectively. Our danger did not consist in this rate of loss alone. The new campaign emphasised the lesson which Mr. Fayle's earlier volumes brought home with so much force. War upon seaborne commerce is made effective as much by dislocating machinery of international trade as by sinking ships. In February, 1917, the first consequence of unrestricted submarine warfare was a dislocation of truly dangerous proportions. Neutrals refused to sail, and the British Government was driven in self defence to re-assert an ancient legal right of requisitioning neutral shipping in war, known as *jus angariæ*.

The shipping controller faced the new situation by speeding up construction at home, by purchasing shipping abroad, and by concentrating shipping upon shorter routes; the Government seconded these measures by a drastic cutting of non-essential imports. The remedies were mere palliatives. "Whatever success might attend the shipping controller's endeavours to speed up construction at home and to acquire new tonnage from abroad, there could be little hope of making good, in this way, the discrepancy between the supply of tonnage and the demand for carrying power. The most that could be expected was that the progressive depletion of the available pool of shipping might be checked by effective replacement of future losses. . . . It was no longer a question of whether losses could be ultimately replaced, but of whether they could be checked or countered before they involved utter disaster." On April 1, 1917, although the situation was full of grave danger, it was, in some respects, more hopeful than it had been a month before. In a few days the position was so black as to be almost hopeless. Up to April 16 the heavy rate of average loss was merely maintained; but on the day following, it rose to an unprecedented total, and the new rate of destruction was maintained for the rest of the month. Between April 1 and 30, 545,000 tons of British and 881,000 of world shipping was destroyed. It was quite obvious that the existing system of naval protection, that of dispersing shipping in the open ocean and of concentrating it later on certain specified, permanently controlled, tracks, had broken down utterly. There remained a remedy which had not been tried—convoy—and naval opinion was sharply divided as to whether it was possible to find a remedy at all. On the one hand a group of old, experienced officers maintained stoutly that we did not possess the naval forces necessary for an operation of such magnitude; on the other, a group of young officers were convinced that with very slight additions to our cruiser squadrons which could easily be made by the Americans, we could provide escort for merchant shipping in the Atlantic and the Mediterranean.

The point of contention was, how many voyages would have to be escorted annually? The Admiralty figures, and those of the Ministry of Shipping did not agree. It is now a matter of common knowledge that the figures upon which Lord Jellicoe based his objections to the convoy system were quite wrong, and one is entitled to ask, why the Admiralty ever relied upon false statistics, when accurate ones were available? Whatever the answer to this serious question may be, one thing is certain; those, who, in the face of technical opposition, gave effect to the convoy system, and those who arranged its practical workings, ought to rank amongst the big figures of our military history. The name of Commander Henderson stands out in the story, and it should certainly be recorded with honour. The history of the submarine campaign from April, 1917, to the date of the armistice is to a certain extent the history of the convoy system. It is perfectly true that we increased German submarine losses by naval means; but it must not be thought for an instant, that, if our improved means of attack had come earlier, they would have averted the tonnage crisis. Mr. Fayle's figures are decisive. Their full implications can only be grasped from the book itself; but even a summary is significant enough. Previous to the introduction of ocean convoys, from 600,000 to 881,000 tons of shipping was being destroyed per month. By the end of 1917, when a regular, though in some respects incomplete, escort system was at work, these figures had been reduced by roughly half (289,000 tons of shipping were destroyed in November); by the autumn of 1918, 146,000 tons of British shipping and 280,000 tons of world shipping was being lost per month.

Although, in this review, emphasis had been laid upon the tonnage question, it must not be thought that Mr. Fayle's work restricts itself to that alone. He treats it as a basic matter, and leaves no room for doubt, that, if British shipping, and the British credit which brought neutral shipping to our ports had failed, the allied coalition would have broken down; but he deals with kindred subjects very fully. Port congestion, the supply of cereals, during 1917 and 1918, the concentration of shipping on the shortest routes, the economic consequences of the Russian collapse, and the position of Europe after the armistice are all dealt with in the impartial, closely documented, manner which is characteristic of the whole book. The author disclaims all intention of drawing conclusions or of pointing lessons, yet, to a careful reader, neither the one nor the other can be doubtful. After surveying Mr. Fayle's work we are entitled to conclude, that, although our maritime resources did withstand the strain put upon them, they need never have been so severely tested. The Government found itself obliged to raise armies for the continent on such a scale that our power to support the coalition by credits, supplies and munitions was sapped from the outset. The origins of the crisis produced by the enemy's submarine campaign, were deeply embedded in the war plan to which we were committed. Had we mustered the elements of our military strength before we decided to send huge armies into Flanders, had we struck a balance

between our capacity to build ships, raise credits, carry supplies and make munitions on the one hand, and our ability to raise armies on the other, had we in fact adhered to our traditional strategy of subordinating our military effort to the far more important problem of placing our maritime resources, and all their derivatives, unreservedly at the disposal of our continental allies, then it is most doubtful whether the German U-boat commanders would ever have sunk tonnage more quickly than we could have replaced it. Intensive production of shipping and war material, unrestricted by shortage of industrial man power, would probably have produced results which would have staggered posterity. Mr. Fayle's book is, therefore, as much the record of a miscalculation as the history of an achievement; but that miscalculation is of such grave import to ourselves that the story of its origin and consequences might well be included among the compulsory subjects of our national education.

Fats: Natural and Synthetic. By W. W. MYDDLETON, D.Sc., Lecturer in Chemistry, Birkbeck College, London, and T. HEDLEY BARRY, Chemist to Messrs. B. Winstone and Sons, Limited. London: Ernest Benn, Limited, 1924. [Price 25*s.* net.]

THE literature descriptive of the technology of oils and fats has increased enormously of late years, and monographs dealing with particular aspects of the general problem have become necessary. In this volume the authors concern themselves with the conversion of the liquid oils into solid fats by catalytic hydrogenation and direct special inquiry into the difference of behaviour of the treated oils and that of the natural fats used in various industries, with the view of tracing the origin of the differences to the several chemical compositions. The book surveys some of the grounds covered in the well-known treatise of Carleton Ellis, but much original work has been done in tracing the changes taking place in the oil during the process of hydrogenation. A satisfactory theory of hydrogenation has yet to be submitted, for the formation of acids of doubtful origin and generally undesirable in the processes of manufacture play a part of considerable importance. The original work of the authors lends support to the suggestion that these acids, which they prefer to denote as "new acids of hydrogenation" rather than regard them as iso-oleic acids, bring about the intermediate formation of a chemical complex, consisting of unsaturated ester, nickel, and hydrogen. According as the supply of hydrogen is in excess or defect, the equilibrium would be moved toward the formation of the saturated ester nickel complex, or "the formation of the complex, unsaturated ester-nickel-hydrogen and the mixture unsaturated ester, nickel and hydrogen."

For the due exhibition of the conditions of the problem and for the sake of clearness, it has been thought desirable to offer a preliminary discussion of the chemistry of oil and to describe the methods of extraction and refinement and of the mechanical processes employed. The details are few, and no attempt is made to indicate the niceties of manufacture as practised in an up-to-date factory, though the methods of clearing the seed, the extraction of the oil (whether by pressure or solvent), and the purification or refining of the extract can be clearly followed. It is satisfactory to know that the precautions against fire have proved successful, or it may be that the consciousness of the imminence of the danger brings its own remedy by enforcing preventive measures that are neglected when safety is apparently secure. This increased immunity from fire makes the choice of a solvent the easier, and the use of benzine, notwithstanding its inflammable character, is apparently superseding that of carbon-tetrachloride and some other solvents which have been proposed. The treatment of cotton-seed oil is given as an example by which the main processes of extraction are effected and the collection of such products as lint, decorticated cake, hulls, &c., can be facilitated.

The process of "rendering" of animal fats as these pass through the factory is also sketched, giving rise to lards, which may pass into margarine manufacture or into tallow and reappear as soap. The oils from fish and marine animals also get a brief mention, and these possess some interest as they can be hydrogenated, and the hydrogenation of unsaturated glycerides has been much practised. This treatment of fish oils is not without its drawbacks and has not been readily accepted, though the view of the authors is, that such hydrogenated products form useful additions to our resources. An objection has, no doubt, arisen from the difficulties of manufacture, since it is found that active sulphur compounds have to be removed, as their presence tends to poison the catalyst very rapidly. With the adoption of measures that remedy this inconvenience the use of fish oil will no doubt increase, but a further objection is that, when used in soap, clothes laundered with hardened fish oil acquire a characteristic fishy smell. To overcome these and other difficulties there seems ample scope for an inquiry into the theory of the process of conversion of oils into hardened fats. Intimately connected with such inquiries is that of the origin of rancidity in order to detect this deterioration in its earliest stages and to take precautions against its appearance.

The mechanics of the fatty acid industry and of the splitting of oils and fats into glycerine and fatty acids are described in a well-balanced summary of the actual conditions, in which the action of the method of bases, of acids, and of the use of animal and vegetable enzymes and ferments is contrasted. In the first-named method the work of Langton is described with sufficient fullness to establish the superiority of magnesia over lime as a fat-splitting agent, both in respect of rapidity and completeness, except in the case of palm oil. The acid process, perhaps, calls for greater care, and as the final product contains more solid acids than the original fat, the process has been found useful in the preparation of candle-making material. The aromatic-aliphatic-sulphonic acids have been proved to possess valuable fat-splitting powers. The authors favour the method of preparation described by Twitchell, claiming that the fatty acids obtained from the hydrogenated oils have good colour and yield soaps of good odour and appearance.

The chapter on catalytic hydrogenation continues the scheme of the authors to combine theoretical research and explanation with the description of mechanical processes, and contains much useful information drawn from current literature. While offering a sketch of the development of the industry, the mechanical processes actually followed are indicated, but many manufacturers must employ devices that have not been published, operating more or less as trade secrets. In the following chapter, on the physical examination of synthetic fats, some critical and valuable remarks are made on the relation between "iodine value" and the melting-point of the hardened product, and here there is scope for further inquiry. It is asserted, too, that the refractive index of the synthetic fats is a more valuable indication of iodine value than melting-point. In the diagrams given it would be satisfactory to know how the refractive index has been determined with the accuracy claimed.

The chemical examination of the hydrogenated product brings more facts to bear on the theory and composition of the new acids of hydrogenation, demonstrating the chemical differences between the natural and synthetic fats. The changes taking place in the oil during the processes of hydrogenation are illustrated diagrammatically, much of the data being made to depend on original work. Not the least interesting feature of these diagrams is brought out by comparison with the recent work of Lush, who shows that in the case of partially hardened olive and cotton-seed oil the amount of the new acids, denoted as iso-oleic acid, can be controlled by the method of treatment. Allowing for the inevitable want of accuracy in the methods of oil analysis, the agreement between the diagrams given by the authors and those reproduced from the work of Lush is striking. In the hydrogenated products in the first case, the catalyst was nickel-mounted on kieselguhr. Lush employed a different plan, in which the surface of nickel turnings was activated by forming a thin layer of oxide and reducing this in a stream of hydrogen. The oil catalyst and hydrogen were brought into contact by two separate methods, and the difference found in the measure of iso-oleic acid was greater than that as found by the authors in one of the methods. There is clearly indicated here a method of controlling, or reducing, the formation of the "new acids," and as these usually act detrimentally in the manufacture of margarine, of soap, of chocolate, and other fats, the economic importance of adequate control can hardly be over-estimated. The authors assert, and many will be inclined to support them, "that it is no exaggeration to say that considerable difficulty has arisen in every industry in which the hydrogenated oils have been called into use." With the view of substantiating this assertion, the authors give some chapters on the uses of fats in various industries. These may prove a little disappointing to both the chemist and the manufacturer. The claims of the two classes are not easy to balance, especially where the space is limited, but, on the whole, the authors have preserved a just division. They have indicated lines of research which may be profitably followed, and the book may well form an encouragement and a stimulant to those who would push investigation further.

BOOKS RECEIVED.

United States Geological Survey. Mineral Resources of the United States. I: 15, *Secondary Metals in* 1922. By J. P. DUNLOP. I: 16, *Gold, Silver, Copper and Lead in South Dakota and Wyoming in* 1922, *Mines Report.* By C. W. HENDERSON. II: 17, *Barytes and Barium Products in* 1922. By G. W. STOSE. II: 18, *Mica in* 1922. By B. H. STODDARD. II: 19, *Slate in* 1922. By G. F. LOUGHLIN and A. T. COONS. II: 20, *Sulphur and Pyrites in* 1922. By H. A. C. JENISON and H. M. MEYER. II: 21, *Silica in* 1922. By F. J. KATZ. II: 23, *Lime in* 1923. By G. F. LOUGHLIN and A. T. COONS. Washington: Government Printing Office.

The University of Minnesota, Engineering Experiment Station. Bulletin No. 3. *Transmission of Heat through Building Materials.* By FRANK B. ROWLEY. Minneapolis: University of Minnesota. [Price 30 cents.]

The Natural History of Crystals. By A. E. H. TUTTON, D.Sc., M.A., F.R.S. New York: E. P. Dutton and Co. London: Kegan Paul, Trench, Trubner and Co., Limited. [Price 15*s.* net.]

Merchant Ship Types. A Survey of the Various Units engaged in the Water Transport of People and Merchandise. By A. C. HARDY, B.Sc. London: Chapman and Hall, Limited. [Price 15*s.* net.]

The Business Directory: London, Suburban, Provincial and Foreign Trade Guide, 1924. London: J. S. C. Morris. [Price 30*s.* net.]

The Association of Engineering and Shipbuilding Draughtsmen. Cam Design and Characteristics. By F. W. Wright. [Price 2*s.*] *The Design of High-Speed Alternating Current Generators.* By William Sharp. [Price 2*s.*] London: Offices of the Association.

The Motor Electrical Manual. Second edition. London: Temple Press, Ltd. [Price 2*s.* 6*d.* net.]

The Book of the Ford Electrical Equipment. By R. T. Nicholson, M.A. Second edition. London: Temple Press, Ltd. [Price 2*s.* 6*d.* net.]

Untersuchungen über den Einfluss der Betriebswärme auf die Steuerungseingriffe der Verbrennungsmaschinen. By Dr. Ing. C. H. GÜLDNER. Berlin: Julius Springer. [Price 1·45 dols.]

Beiträge zur Technischen Mechanik und Technischen Physik. Berlin: Julius Springer. [Price 2·30 dols.]

Pulverised Fuel, Colloidal Fuel, Fuel Economy, and Smokeless Combustion. By LEONARD C. HARVEY. London: Macdonald and Evans. [Price 42*s.* net.]

The Control of the Speed and Power Factor of Induction Motors. By MILES WALKER, M.A., D.Sc. London: Ernest Benn, Ltd. [Price 18*s.* 6*d.* net.]

The Journal of the Institute of Metals. Vol. XXX. 1923. Edited by G. SHAW SCOTT, M.Sc. London: Offices of the Institute. [Price 31*s.* 6*d.* net.]

Appendix to B.O.T. Orals. By W. C. MACGIBBON, M.I.Mech.E. Glasgow: James Munro and Co., Limited. [Price 10*s.* net.]

Die Rationalisierung im Deutschen Werkzeugmaschinenbau, By Dr. FRITZ WEGELEBEN. Berlin: Julius Springer. [Price 1.70 dols.]

Neuzeitliche Vorkalkulation im Maschinenbau. By FR. HELLMUTH and FR. WERULI. Berlin: Julius Springer. [Price 1.45 dols.]

Die Theorie elastischer Gewerbe und ihre Anwendung auf die Berechnung beigsamer Platten. By Dr. ING. H. MARCUS. Berlin: Julius Springer. [Price 5 dols.]

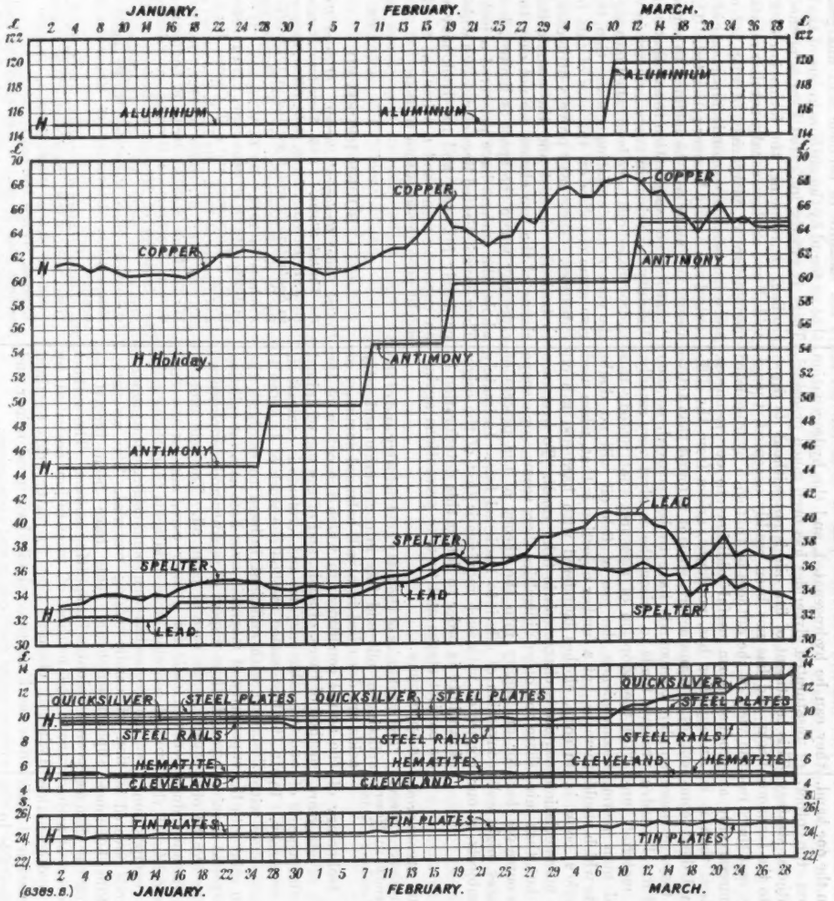
Bruno Kerl's Probierbuch. Zur Untersuchung von Erzen und Hüttenprodukten. By Dr. CARL KRUG. Leipzig: Arthur Felix.

The Physics and Chemistry of Mining. An Elementary Class-Book for the Use of Mining Students. By T. H. BYROM, F.I.C. Fifth edition. London: Crosby, Lockwood and Son. [Price 6*s.* net.]

PERSONAL.—The Cunard Company announce the appointment of Mr. G. McL. Paterson, B.A., M.I.N.A., to the position of naval architect, rendered vacant by the death of Mr. Leonard Peskett. Mr. James M. Dewar, M.I.Mech.E., M.I.N.A., has taken offices at 1, Charing-cross, London, S.W. 1, where he will act as consulting marine engineer and naval architect.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN THE PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal and Scotch Pig-Iron Warrant Markets.)



NOTE.—In the diagrams the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange for fine "foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. Middlesbrough prices are plotted for steel plates and rails, and also for hematite and Cleveland pig-iron. The prices given, in the case of steel plates and for ship, bridge and tank qualities, and those for steel rails are for heavy sections. The pig-iron prices are for East Coast hematite and Cleveland iron, both of No. 1 quality and for home consumption. The price of quicksilver is per bottle, the contents of which vary from 70 lb. to 80 lb. The price of tin-plates is per box of I.C. cokes f.o.b. at Welsh ports, but in other cases the prices are per ton. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each.

INTERNATIONAL CEMENT CONGRESS.—An International Cement Congress will be held on April 22 to 24 inclusive, for which the following programme has been arranged by the Institution of Structural Engineers:—April 22, at 11 a.m., in the Small Conference Hall, at the Building Exhibition, Olympia, the party will assemble to be conducted round the Exhibition. At 1.0 p.m., delegates will be entertained at luncheon by the Council of the Institution. From 3.0 p.m. to 6.30 p.m. papers will be discussed. On Wednesday, delegates will visit Gravesend by river and go over the Kent Portland Cement Works, assembling at 9.30 a.m. at the Old Swan Pier Landing Stage, London Bridge. On Thursday, the 24th, a visit will be paid to the British Empire Exhibition, at Wembley. A variety of subjects are down for discussion, including Ciment Fondu in practice; Cement in Sea Water; Surface dust on concrete floors; Preparations to withstand oil; Porosity of Concrete Blocks; Influence of size and shape in compression test blocks; Causes of change in the setting time of Cement; Microscopy of Cement; The Use of Sea Water in Mixing; etc.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—At the annual general meeting of this institution, held on March 25, Dr. W. R. Ormandy was elected president for the session 1924–1925. The next meeting will be held at the Institution of Civil Engineers, on Wednesday, the 9th inst., at 6.30 p.m., when Mr. L. A. Legros will lecture on "Traction across Rough and Roadless Country."

ASH-HANDLING PLANT AT WEMBLEY EXHIBITION: ERRATUM.—We regret by an obvious slip the speed of rotation of the paddle wheels of the Babcock and Wilcox ash-handling plant, illustrated in our issue of March 21, was given as 45 r.p.m., instead of per hour. The nature of the mechanism employed would render the error at once apparent to the reader.

THE INSTITUTION OF AERONAUTICAL ENGINEERS.—Minutes of Proceedings, No. 7, of this Institution, which have just been issued, contain a reprint of two papers on "Welded Steel-Tube Construction" and "The Development of Cantilever Wings," read by Mr. A. H. G. Fokker, at a meeting held in November last; a report of the discussion is also included. Copies of this publication can be obtained from the offices of the Institution, 90, Chancery-lane, W.C.2, price 1s. 6d. net; 1s. 8d. post free.

HIGH-SPEED WOOD-PLANING MACHINE.

CONSTRUCTED BY MESSRS. THOMAS WHITE AND SONS, LIMITED, LAIGHPARK, PAISLEY.

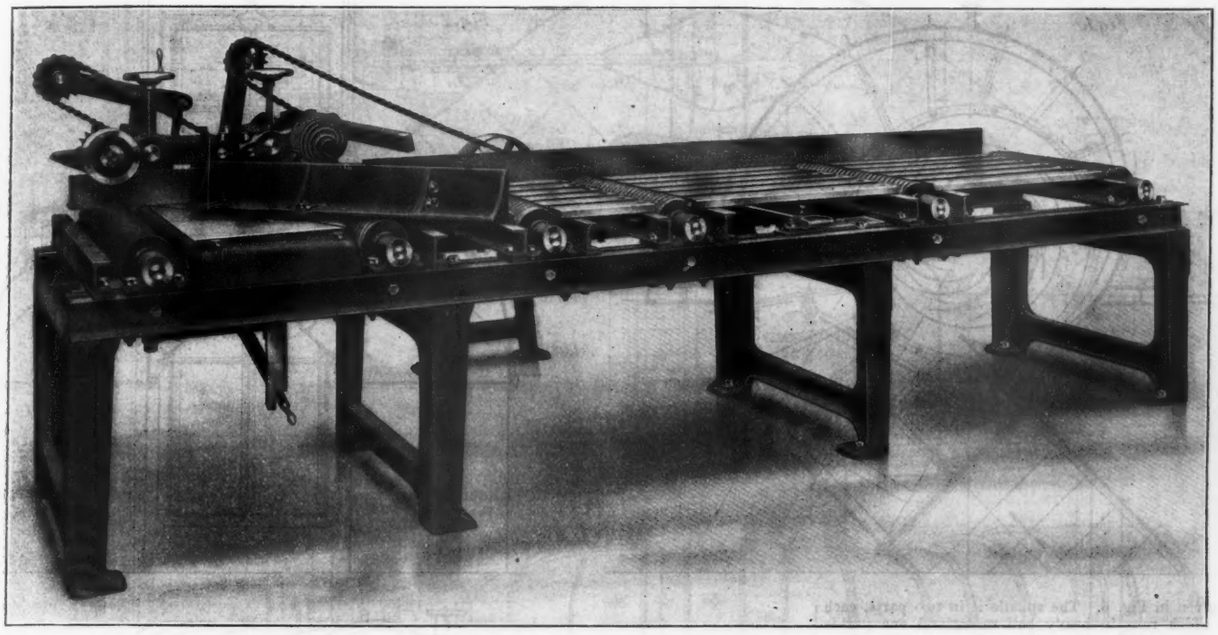


Fig. 3. Automatic Feed Table.

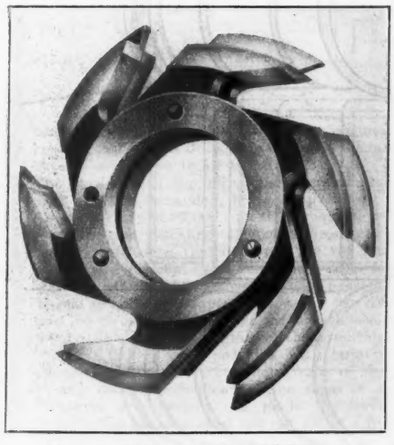


Fig. 4. Solid Grooving Cutter.

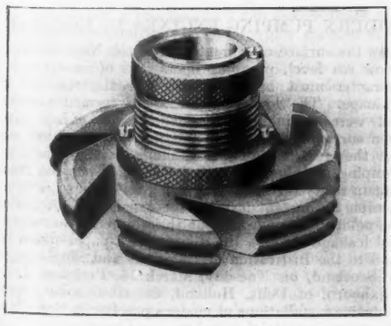


Fig. 5. Solid Profile Cutter and Sleeve.

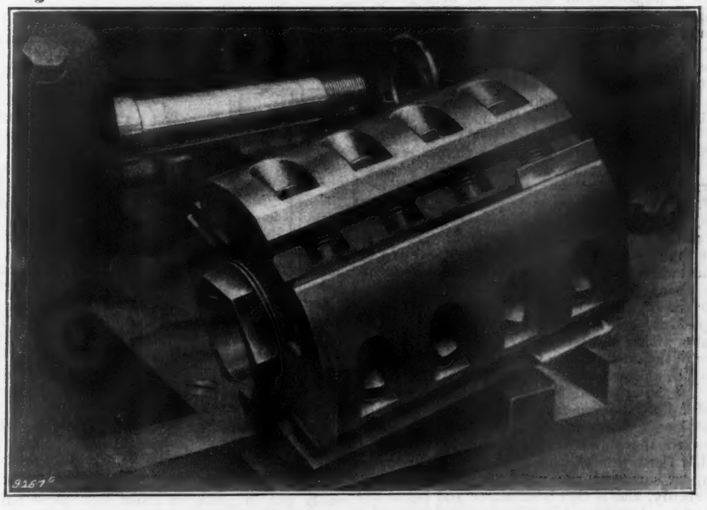


Fig. 6. Loose Block Head.

To obtain very high speeds in planing timber is essential to cheap production, but is only possible in machines of which every part has been designed to meet the onerous conditions. The work, no matter what may be the rate of its performance, must show the characteristics of quality for which there is a demand, and all the components of the machine must work in harmonious relationship to one another, to give a good class of product. Because of the many improvements introduced to meet the changed conditions, it may be said that the product from a high-speed wood-working machine of to-day shows no falling away from the established standards for different classes of work, and that the new demands for speed have been successfully met. As an example of a machine designed for the production of flooring boards and other repetitive planing work, illustrations are shown on page 436 and above of a planing machine constructed by Messrs. Thomas White and Sons, Limited, of Laighpark, Paisley. This machine is capable of completely planing timber up to 12 in. by 5 in. in section at the rate of 300 ft. per minute.

In Fig. 1, page 436, a general view of the complete machine is shown. The timber is fed in at the far end by the use of an automatic feeding table, which will be referred to later. As the timber enters the machine it is passed between the first set of feed rollers which are of 18 in. diameter, and are driven at a speed to suit the class of work. The gear box installed gives nine different speeds, ranging from that equivalent to a feed of 58 ft. per minute up to one of 300 ft. per minute. Easy working with little wear and tear was the aim of the designer in arranging this equipment, and consequently ball bearings are used on every spindle, and the gear box is kept flooded with oil, while the gear wheels are made of heat-treated and oil-hardened steel. The drive from the gear is taken to the feed rolls through a worm and worm wheel. There is a second set of feed rolls halfway along the machine, and both groups are connected by a chain of the bush roller type. Just after passing through the first set of feed rolls the timber reaches the bottom head. This is equipped so that it may be raised or lowered to suit the requirements and also may be drawn out for the replacement of the block. In this case, as in all the other heads of the machine, the loose spindle is so constructed that the block can be removed and replaced without disturbing the bearings. An illustration of the arrangement which makes this possible

MODERN PUMPING ENGINES IN HOLLAND.

Fig. 1.

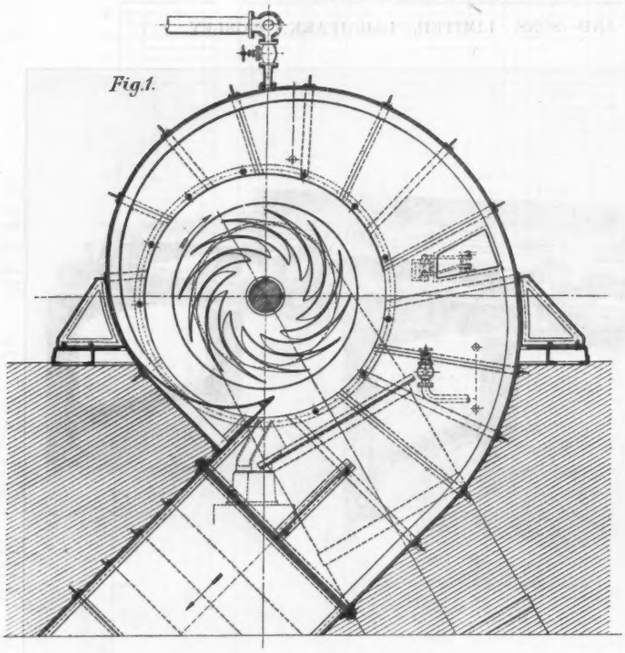
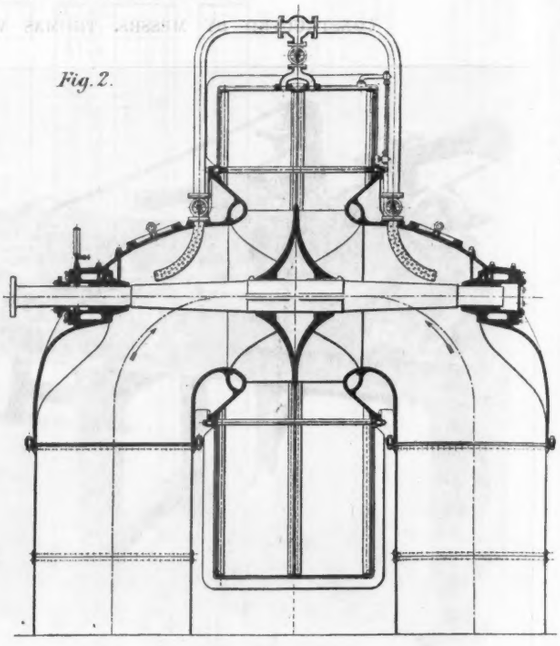


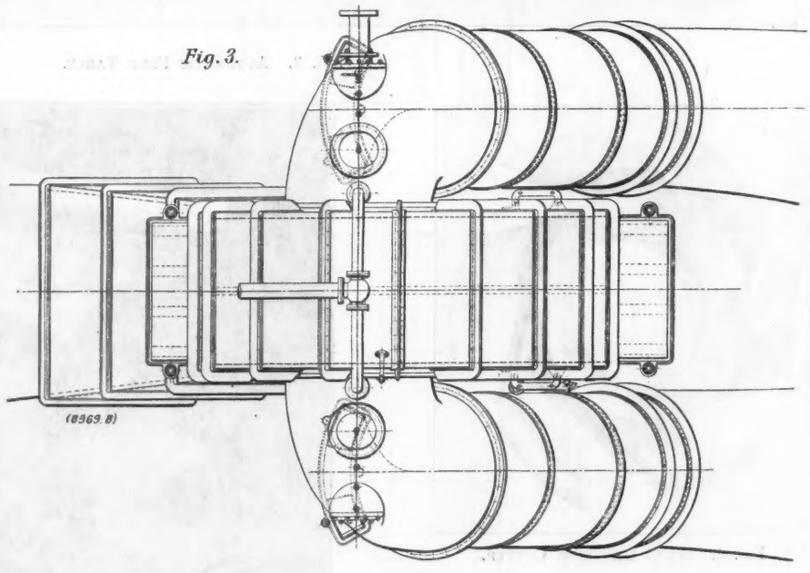
Fig. 2.



is given in Fig. 6. The spindle is in two parts, each of which runs in heavy ball races, and one part is screwed into the other at their junction. The drive is given to that part which is just shown projecting through its bearing on the right in Fig. 6, while the other part is tapered and screwed to fit into the driving portion. The head is fastened to the spindle by two coned collets and part of the radial load is taken by a key. The loose part of the spindle is squared to receive a spanner, so that the two portions may be separated. Removal of the head from the tapered pindle is facilitated by screwed collets, the front one of which is shown in position on the head, on the left in Fig. 6.

After passing the bottom head, the timber reaches a set of four fixed planing blades, and the work is held down to them by the pressure rollers above. All the four knives are not generally in use at the one time, and they are accommodated in separate drawers, and can be instantly lowered from the cutting position by the handles seen at the front (Figs. 1 and 2) and withdrawn. Easy and quick adjustment of the pressures upon the timber is possible either for any particular set of rollers or for all at once, and they may be put into or out of action at will. Below the fixed blades within the bed of the machine, and thus not shown in the illustrations, there is a shaving cutter, which may be stopped or started from the front of the machine. It is arranged so that it may be easily connected up to the general exhausting system. In its further passage through the machine, the timber goes between the rolls of the second feed system, and reaches the top head where the block for planing on the upper surface is mounted. This head is particularly sturdy, and is tied both above and below the platen, and freedom from vibration, which is essential to good work, is thus ensured. The same type of spindle in use for the bottom head (Fig. 6) is installed here. This spindle is of sufficient strength to carry a heavy eight-cutter circular block. The pressure systems in front and immediately after the top-cutter blocks are of a design to prevent any chattering action. These rise and fall with the cutter head, but are independently adjustable. The next operation is side planing with rotary cutters on heavy spindles. These again are mounted on ball bearings. Fig. 4 shows the design used for the grooving of the timber, and Fig. 5 shows a solid profile cutter. After the rotary side heads, there are side fixed knives for the purpose of correctly finishing to width. These are fully adjustable and slide on heavy planed ways. Last of all, there is a beading head which may be either single or double. It is arranged, when of the double type, for running with solid profile cutters and each spindle is independently adjustable. The back table may be swung away for access to these cutters. When a single spindle is used, it takes the form of the loose type, and may carry either a square block or a solid profile cutter. Each head of the machine is provided with truing devices which may be easily put in place, in order that those adjustments necessary to ensure that every cutter does its proper share of the work may be readily made.

Fig. 3.



The feeding table, already referred to, is shown in Fig. 3. By the use of this device, the timber once placed on the table is directed into the machine in a regular and automatic way. The rough spirals on the drums serve to bring the timber to the feeding axis when the spiral cone presses against the top of the piece which is in place and forces it through the gap between the back board and the inclined guide end and into the planing machine. In this part of the equipment slack in the chain is automatically taken up no matter what is the thickness of the timber which is being fed into the machine. An adjustable set block prevents one piece climbing on another. Other features of this feed table are the ready means of stopping all action instantly, which operation may be worked from either end of the table, and of the method of lifting the rolls.

INTERNATIONAL CEMENT CONGRESS.—An International Cement Congress, under the ægis of the Institution of Structural Engineers, will be held at Olympia during the course of the Building Exhibition. The congress meetings take place on the 22nd, 23rd and 24th inst.

MODERN PUMPING ENGINES IN HOLLAND.

As the surface of a great part of the Netherlands is below sea level, pumping operations of an extensive character must be resorted to for the removal of drainage. The low-lying areas are termed polders, and were originally lakes or marshes. They have been surrounded by dikes and the water pumped out for the reclamation of valuable land. Whatever pumping machinery is installed for this purpose must remain ready for use at any time, to keep as nearly as possible a constant level in the canals and ditches of the polders, by pumping out the water due to rainfall and leakage through the dikes. In a paper which he read to the Institution of Engineers and Shipbuilders in Scotland, on Tuesday, March 18, Professor J. C. Dijxhoorn, of Delft, Holland, described some representative installations of modern practice in this phase of engineering, and detailed the considerations involved in the design. We report the paper in abstract.

Until three centuries ago the drainage of the polders was effected by scoop wheels and open-water screws driven by windmills. These were replaced during the nineteenth century by steam plants and the number of windmills has since been much diminished. Now, he continued, many centrifugal pumping engines for

MODERN PUMPING ENGINES IN HOLLAND.

Fig. 4.

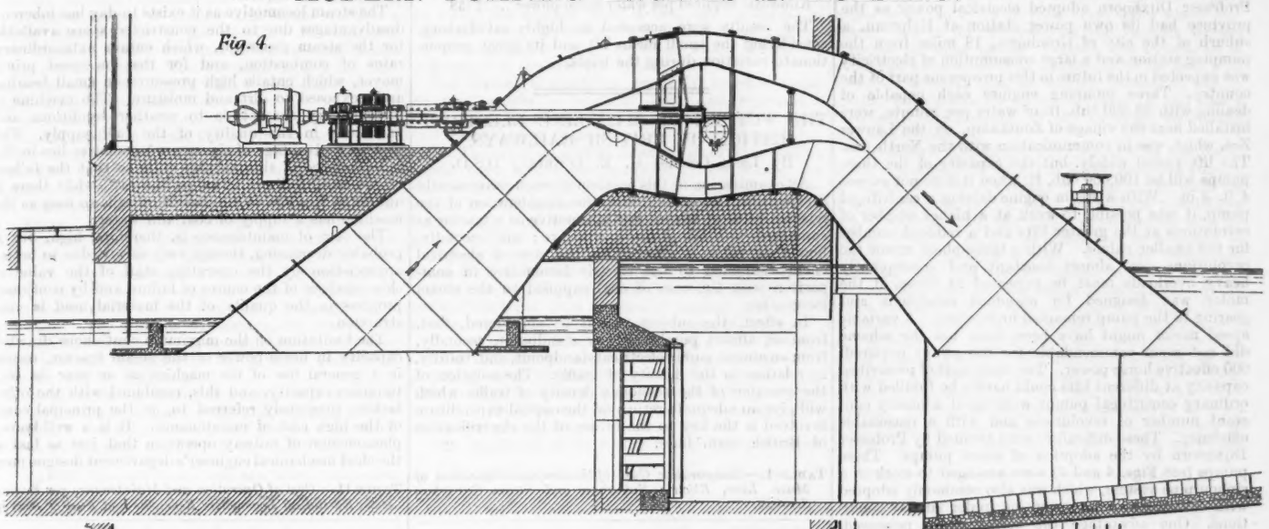
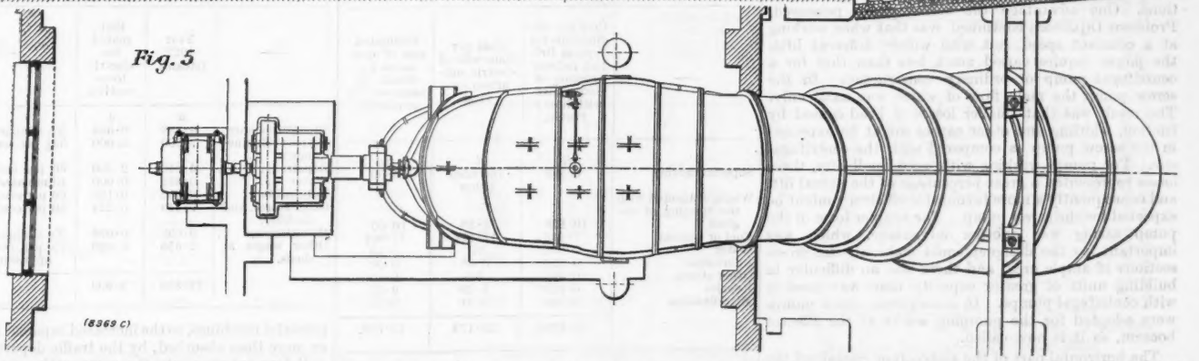


Fig. 5



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drainage work were driven by steam engines, Diesel engines, gas engines or electric motors and examples of these classes were to be found all over the country. The capacities of the individual pumps varied as the circumstances demanded, but generally were between 1,400 cub. ft. and 14,000 cub. ft. per minute. Most of them did not discharge the water from the polders directly into open rivers or into the sea but into a system of connected canals and small lakes forming a type of intermediate reservoir called a boezem. From several of these the superfluous water was discharged into the rivers or into the sea through sluices, when it was possible to take advantage of the lower tides on the outside. Others were provided with large pumping engines to discharge the combined water of the polders at any time, independent of the state of the tide. Whatever arrangement was made the level of the water in the boezems must not rise above a fixed limit because of possible damage to the dikes of the polders, nor must it fall below the level required for shipping.

The greatest boezem of the Netherlands was that of Friesland, a province of 1,280 square miles. In 1912 the Government of the province decided to replace the old sluice method of dealing with superfluous water by the use of pumps capable of discharging 140,000 cub. ft. per minute into the Zuider Zee, near Lemmer. When the larger works at present contemplated on the Zuider Zee were finished a lake, with an outlet to the North Sea through a number of sluices, will be left, and when that was ready the water at present dealt with in the Lemmer scheme will be discharged into this great lake. At the beginning of 1914, when the scheme was under consideration, the price of crude oil was very high, and Diesel engines were thought to be outside any possibility of economic use. Electrical driving, because of the small period of use of the pumps, amounting to an average of only 45 days a year and the difficulties of getting adequate supplies, was also thought to be entirely unfavourable. Steam power was chosen and four tandem compound engines were installed, each of which drives two centrifugal pumps of imposing dimensions. Steam was generated in six two-storey boilers, each consisting of a Lancashire boiler below with a multitubular boiler above, and working at a pressure of 170 lb. per square inch. Each boiler had 2,540 sq. ft. of heating surface and had a superheater of 920 sq. ft. surface, which raised the temperature of the steam to about 600 deg. F. Under any circumstances five of these units would prove ample for the work. The boilers were hand fired, as the working year of the plant was not considered long enough to obtain the full benefits of mechanical stokers.

The main steam engines in this installation had a single acting H.P. cylinder and a double acting L.P. cylinder of the uniflow type. The dimensions are: H.P. diameter, 19¾ in.; L.P. diameter, 32½ in.; and the stroke was 39⅜ in. The two valves of the H.P. cylinder, inlet and exhaust, and the two inlet valves of the L.P. were all of the piston type, and operated by motion taken from a side shaft, driven by bevel gearing. The front end of the H.P. cylinder acted as an intermediate receiver, and the actions were arranged on James Watts' well-known Cornish cycle, which it was thought by Professor Dijxhoorn, who designed the plant, would give economical results. The design of the eight main centrifugal pumps is illustrated in Figs. 1 to 3. Each has a capacity of 17,500 cub. ft. per minute. The pump casings were constructed of ½ in. plates and angle iron, and all the seams were welded. Stiffening was effected by T-irons on the outside and by distance bolts inside. This was necessary as the inside water pressure was below the atmospheric value even at the discharge end, the pump being above the level of the sea into which it discharged. The cast-iron curved suction pipes joined the pump casing at each side, and had an inside diameter of 7 ft. 10½ in. The bearings supporting the 8-in. pump shaft were fitted with gun-metal liners at both sides, the bearing at the engine side being also provided with a stuffing box. Pipes made up of rolled steel are joined to the cast-iron bends and passed gradually into horizontal inlet pipes, rectangular in section and constructed of reinforced concrete. For the eight pumps there were sixteen inlet openings of dimensions 9 ft. 10 in. by 5 ft. 3 in. The discharge was rectangular, 6 ft. 7 in. by 5 ft., and gradually curved into a horizontal outlet pipe of reinforced concrete with an opening 16 ft. 5 in. by 6 ft. 7 in. To deal with the enormous quantities of water delivered at small heads the pump wheel had the form of a drum with a diameter of 5 ft. 7 in., and a breadth at the cimcumference of 3 ft. 2½ in. The wheel was cast iron with steel blades ⅝ in. thick. These blades were curved in two directions like the blades of a Francis water turbine. Because of this, the pump not only worked on the centrifugal principle, but also had a secondary screw action. There were no return valves to the pumps, and consequently the starting of the engines and the filling of the pumps must take place at the same time. A central vacuum vessel, in form a vertical cylinder 3 ft. 3 in. in diameter and 20 ft. high, was provided to withdraw the air and thus fill the pumps with water. This vessel was first evacuated by the air pumps of the condensers or by a powerful steam exhauster. When the stop valve between this vessel and any pump was opened, air first entered it, and afterwards a mixture of air and water passed through. The water was discharged at the foot of a pipe, the mouth of which was submerged in the sea, and while this proceeded the exhaustion of air was continued from above. By this means the filling of the big centrifugal pumps was completed in a few minutes.

Careful tests were made at the Lemmer Pumping Works on January 25 and 26, 1923, to ascertain the capacity of the pumps and the steam consumption of the engines. The capacity was tested with lifts of about 2 ft. as there was no opportunity of making tests with higher values at the time.

Mean lift. In.	R.p.m.	Cub. ft. per minute.
22½	95	1,783
24 7/16	100	1,852
24⅝	105	2,055

when the consumption was measured the lift was even smaller, varying from 1 ft. 5 15/16 in. to 1 ft. 7 11/16 in. The mean results of two trials which only showed small differences, were as follows:—

R.p.m.	100·15
Mean lift, in.	18¼
Water discharged per minute, cub. ft. ...	2,209
Water horse-power of four pumps driven by two engines	240·9
Indicated horse-power of the two engines	876·4
Total efficiency ... ... W.H.P. / I.H.P. =	0·275
Steam pressure at stop valve, lb. per sq. in	149·6
Steam temperature	589° F.
Mean vacuum in condenser, in.	28 1/16
Total steam for two engines, including condensation in steam pipes and consumption of auxiliary pump for condensers, &c., lb. per hour	8,406
Steam consumption per i.h.p. per hour (lb.)	9·59

In another large installation for which he was responsible, that of the Government of Groningen, Professor Dijxhoorn adopted electrical power as the province had its own power station at Helpman, a suburb of the city of Groningen, 18 miles from the pumping station and a large consumption of electricity was expected in the future in this prosperous part of the country. Three pumping engines each capable of dealing with 33,300 cub. ft. of water per minute, were installed near the village of Zoutkamp, on the Lauwer Zee, which was in communication with the North Sea. The lift varied widely, but the capacity of the three pumps will be 100,000 cub. ft. when it does not exceed 4 ft. 3 in. With a steam engine driving a centrifugal pump, it was possible to work at a higher number of revolutions at the greater lifts and a reduced number for the smaller values. With a three-phase motor the revolutions were almost constant and consequently heavy overloads must be expected at times, if the motor was designed for standard conditions and gearing to the pump remained unchanged. A variable speed motor might have been used, but the scheme did not seem commendable for the power required, 600 effective horse power. The conditions of prescribed capacity at different lifts could hardly be fulfilled with ordinary centrifugal pumps working at a nearly constant number of revolutions and with a reasonable efficiency. These difficulties were avoided by Professor Dijxhoorn by the adoption of screw pumps. These pumps (see Figs. 4 and 5) were arranged to work in a siphon pipe system, which was also commonly adopted with centrifugal pumps working under similar conditions. One advantage the screw pump possessed, Professor Dijxhoorn continued, was that when working at a constant speed, but with widely different lifts, the power require varied much less than that for a centrifugal pump of ordinary construction. In the screw pump the main flow of water was axial only. The result was that smaller losses of head caused by friction, whirling and other causes might be expected in the screw pump as compared with the centrifugal one. For pumps working with very small lifts, these losses represented a great percentage of the actual lift, and consequently a more favourable efficiency might be expected for the screw pump. The simpler form of the pump casing was another advantage, which was important, as the designer could make all the cross-sections of ample area, and there was no difficulty in building units of greater capacity than was possible with centrifugal pumps. In consequence screw pumps were adopted for the pumping works at the Electra boezem, as it is now called.

The horizontal part of the siphon pipe contained the working system. The screw was keyed to a horizontal shaft, and in the direction of the waterflow there was a circle of curved guide blades which led the water into an exactly axial direction. Only the outside ring section of the pump was active; the central part was hollow, and double pear shaped (see Fig. 4). The centre piece of the pump wheel was conical. The casing and the centre piece were made of cast-iron segments. There was a horizontal flange-joint at the centre line to make the pump wheel and the bearings of the shaft at both sides of the wheel readily accessible. The centre piece of the pump wheel was also made of cast iron, but the screw blades were made of steel plate ½ in. thick, and fixed to flanges on the conical centre piece and joined by angle iron ½ in. thick to the conical rim plate of the wheel. The inside diameter of the wheel at the discharge side was 11 ft. 7½ in. The conical suction pipe changed from 12 ft. 9 in. diameter at the inlet opening to 9 ft. 10 in. diameter at the connection with the pump casing, while the discharge pipe varied from 9 ft. 10 in. to 13 ft. 2 in. diameter. From these dimensions some idea could be obtained of the magnitude of the plant. At normal load the three-phase 3,000 volt electric motor ran at 978 r.p.m. and the power was transmitted to the pump at 53 r.p.m. through double gearing. The pumps were filled by the use of the same system of evacuation cylinder as was used at Lemmer, but the vacuum pumps were electrically driven. When a screw pump was evacuated in this way the pump first worked at a quarter of the blade wheel diameter, then it gradually reached a half, and so on, the load on the motor increasing gradually until the evacuation was completed. An emergency valve allowed air to enter the pumps automatically and thus emptied the water when such an action as the failure of the electricity took place. Difficulties were experienced in 1918 in completing the aerial line for the power station and a provisional steam-driven electric plant was installed in the station on the side of the proposed fourth and fifth sets. The results of the trials may be summarised as follows, the figures being the averages obtained with lifts varying between 2 ft. 1½ in. and 4 ft. 3½ in.:—

Revolution of pump shaft per minute ...	53·2
Mean lift of pump, in.	44
Water discharged by each pump, cub. ft. per hour	35,564
Water horse-power developed by each pump	246·4
Mean kilowatts required for each pump motor	341
Kilowatts required per water horse-power...	1·38

The results were accepted as highly satisfactory, considering the small mean lift and its great proportionate variation during the trials.

THE FUTURE OF MAIN-LINE ELECTRIFICATION ON BRITISH RAILWAYS.*

By Lieut.-Colonel H. E. O'BRIEN, D.S.O.

AN examination of this problem is most conveniently divided into two parts: first, the consideration of the relative value of the electric locomotive as a tractor as compared with the steam locomotive; and secondly, how that value is affected by the cost of electrical energy supplied to the electric locomotive in comparison with the cost of coal supplied to the steam locomotive.

In effect, the subject should be considered, first, from an almost purely railway standpoint, secondly, from an almost purely electrical standpoint, and, thirdly, in relation to the density of traffic. The solution of the question of the economic density of traffic which will give an adequate return on the capital expenditure involved is the key to the future of the electrification of British main lines.

TABLE I.—*Comparative Cost of Locomotive Operation of Main Line, Electric Suburban and Steam Suburban Services.*

—	Cost per engine-mile for typical British railway (steam) of large size with heavy traffic.	Cost per train-mile of electric suburban services	Estimated cost of operation by steam of same service as electric.
	d.	*d.*	*d.*
Superintendence ..	0·538	Included below	0·50
Wages connected with the running of engines	10·158	3·36	10·00
Fuel or current ..	7·842	17·41†	12·00‡
Water	0·331	Nil	0·50
Lubricants	0·352	0·08	0·50
Other stores	0·449	Nil	0·40
Repairs	6·910*	5·28	9·00
Miscellaneous ..	0·098	0·04	0·10
	26·678*d.*	26·17*d.*	33·00*d.*

* The cost of locomotive maintenance per engine-mile includes boiler renewals, overhead charges to cover supervision, clerical staff and office expenses, also workshop overhead charges, such as foremen's, clerks, and draughtsmen's wages, maintenance and renewal of machinery and plant including tools and general workshop expenses but excluding maintenance of buildings, rates and taxes, interest, depreciation, head office expenses and complete renewal of locomotives.

† Includes interest, depreciation and maintenance of power station, h.t. transmission, substations and track equipment.

‡ Tests made on the Liverpool and Southport electrification when a steam-hauled service was run to electric service schedule times showed the coal consumption to be 100 lb. of coal per engine-mile.

Mr. Roger Smith† has already dealt with the subject, using the number of locomotives per mile of track as a basis, and Mr. H. Parodi of the Paris-Orleans Railway in a recent paper‡ has also used as a basis the coal consumption per mile of track. It appears to the present author, however, that for British conditions the subject may be more clearly considered by using the engine-mile as a basis, as this is a figure readily obtainable and already considerably used for comparative purposes in railway work.

It is true that the engine-mile, though a concrete fact, has a somewhat indefinite meaning, inasmuch as no value of work done attaches to it. The ton-mile is really almost as indefinite in this sense as the engine-mile, as in both cases all reference to the time factor is omitted. The average time factor or speed of trains can, however, be taken as a constant for any English main line, but the average weight of train, as will be seen later, varies somewhat. In considering averages (a method which is forced on the investigator by the existing statistical methods of English railways) deductions may, however, be safely drawn as to the probability of higher values than the average existing, when it is known that a large proportion of the whole represents lower values—the speed and weight of trains on branch lines will obviously be less than on the main line. It will be necessary to consider quantitative figures, for the essence of the problem is financial, and the decision whether or not to electrify portions of the British main lines will rest with financiers rather than with technical experts.

The steam locomotive as it exists to-day has inherent disadvantages due to the constricted space available for the steam generator, which entails extraordinary rates of combustion, and for the low-speed prime mover, which entails high pressures on small bearing areas exposed to dirt and moisture. The machine is further very susceptible to weather conditions and variations in the quality of the fuel supply. The principal advantage of the steam locomotive lies in the independence of the tractive units so that the failure of one has no direct effect on the rest, while there is unlimited freedom of movement on rails so long as the machine has a supply of coal and water.

The cost of maintenance is, therefore, high, but is probably decreasing, though very slowly, due to better appreciation by the operating staff of the value of close analysis of the causes of failure and by continued progress in the quality of the material used in construction.

The limitation on the maximum continuous drawbar capacity in horse-power of the steam tractor, results in a general use of the machine at or near its continuous capacity, and this, combined with the other factors previously referred to, is the principal cause of the high cost of maintenance. It is a well-known phenomenon of railway operation that just as fast as the chief mechanical engineer's department designs more powerful machines, so the increased capacity is absorbed, or more than absorbed, by the traffic department.

TABLE II.—*Cost of Operation and Maintenance per Engine-Mile, Excluding Locomotive Renewals and Fuel or Energy.*

—	Year 1922 (steam).	Estimated for electric locomotive.	—
	d.	*d.*	
Superintendence	0·538	0·538	No change.
Wages: Enginemen's	7·500	5·000	33⅓ per cent. reduction.
Repairs	6·910	2·300	66 per cent. reduction.
Water	0·331	0·000	Eliminated.
Lubricants ..	0·352	0·120	66 per cent. reduction.
Other stores, and clothing.	0·449	0·224	50 per cent. reduction.
Miscellaneous ..	0·098	0·098	No change.
Other wages at sheds.	2·658	0·620	75 per cent. reduction approximate.
	18·836	8·900	

Before entering into the comparative advantages of the electric tractor in relation to the above, it is necessary to examine very briefly other possible improved forms of tractor. The turbo-electric locomotive may be quickly dismissed: the weight per draw-bar horse-power is much higher than that of the steam locomotive, it requires more skilled attention, the first cost must be higher than that of an electric locomotive and very much higher than that of a steam locomotive, and a crew of two, if not of three, men is required. The possible advantages are a saving in fuel and, possibly, reduced boiler repairs due to condensate being available for a portion of the boiler feed. The straight turbine locomotive seems to have more possibilities, but here again only a saving in fuel and a possible saving in boiler repairs can be offset against increased weight and complication.

The internal-combustion locomotive is still in swaddling clothes; suffice it to say that only prolonged and expensive research shared by a large railway company and a manufacturing firm with ample resources is likely to result in the production of a practical tractor of 800 to 1,500 draw-bar horse-power capable of continuous service in traffic. If, and when, such a machine is produced costing no more than a steam locomotive, with a fuel consumption in money value of less than half that of the steam tractor, a possibility of multiple operation with a single crew and a demonstrated lower cost of repairs, then the electric locomotive will have a serious rival.

The electric locomotive compared purely as a tractor with its steam rival, leaving out of account all question of the cost of fuel or energy supplied for a given service, has the following advantages:—(1) Capacity for almost continuous service in traffic. (2) Low cost of repairs. (3) High tractive capacity per unit. (4) Low weight per continuous draw-bar horse-power available. (5) Reliability in service. (6) Complete independence of weather conditions. (7) Even turning effort. (8) High mechanical efficiency and large range of maximum efficiency. (9) Possibility of operation as a unit or in multiple by one man. (10) Reduction of signal movements and occupation of tracks due to elimination of necessity for turning and movements for obtaining coal and water and daily visits to sheds. (11) Much greater flexibility of wheel base. (12) Large overload capacity available instantaneously.

The disadvantages are the number of units which

* Abstract of paper read before the Institution of Electrical Engineers on Thursday, March 27.

† Société des Ingénieurs Civils de France (British Section), Presidential Address, 1923–24.

‡ "Electrification Partielle du Réseau de la Compagnie du Chemin de Fer d'Orleans." *Bulletin de la Société Française des Electriciens*, ser. 4, vol. 3, No. 23.

may be immobilized by a failure of energy supply, and the dependence of each unit for mobility on contact with the electrical distribution system of the track. In a mixed system of electric and steam traction a further disadvantage is the necessity for changing from steam to electric traction at the terminal points of the steam section. The economic length for electrification may not coincide with the natural economic length of run for a steam locomotive.

The question of the change of locomotive from steam to electric, and vice versa, has an important bearing on the financial aspect of main-line electrification. While such changes may be almost eliminated when a complete scheme of electrification has been carried out, the impossibility of dealing with an electrification of 1,000 or 1,500 track-miles except by stages, together with the fact that in general the maximum economic length of run of a steam locomotive is not more than 160 miles, may necessitate a considerable expenditure in the initial stages on temporary accommodation for steam locomotives at the temporary termination of each stage; nor will the expenditure be confined to locomotive housing alone, as accommodation will have to be provided temporarily for a large number of staff who will be displaced.

While given the conditions necessary for a successful electrification, viz., cheap current and requisite density of traffic, a limited scheme might not be a financial success, at the same time it will be clear that the full mileage per steam locomotive per annum and may be used comparatively in considering relative costs.

The cost of repairs per train-mile varies from 2·1*d.* to 6·0*d.*, the average being 4·18*d.*, the variations in this case being due to differences in the design and age of the equipment and, to some small extent, to differences in the schedule speeds.

The steam locomotives probably average about 80 tons' weight in working order, and represent a present-day lowest market value of about 4,000*l.* each and a maximum draw-bar horse-power of probably 800. The average steam locomotive of this weight would have been quite incapable of performing the electric suburban service, and the comparison really should be with locomotives weighing 120 tons, costing 8,400*l.* each, and having a maximum draw-bar horse-power of 1,200.

The electric motor-cars, on the other hand, average about 60 tons for the tractor part of the train equipment including the weight of the motor bogies, cost about 8,000*l.* per train at present market prices, and have a continuous draw-bar horse-power of 1,400.

Table I shows a comparison between (1) The average cost of all steam services, passenger, freight and shunting, on a typical British railway system; (2) The average cost of a high-speed electric passenger service; (3) The estimated cost of operating the electric service by steam.

This conclusion is confirmed by Sir Philip Dawson

TABLE III.—TYPICAL COST PER UNIT DELIVERED TO H.T. FEEDERS, BRITISH GENERATING STATIONS.

Station.	A	B	C	D	Typical railway power station supplying suburban electrification.	Estimate for main-line generating station.
Load factor, per cent	25·3	31·2	25·2	—	40	50
Coal per unit, lb.	1·86	1·95	2·4	1·9	2·4	1·8
	d.	*d.*	*d.*	*d.*	*d.*	*d.*
Coal	0·1495	0·1839	0·1929	0·1300	0·1980	0·1430
Oil, waste, &c.	0·0035	0·0043	0·0050	0·0050	0·0020	0·0020
Repairs	0·0352	0·0345	0·0463	0·0500	0·0350	0·0250
Salaries and wages	0·0415	0·0482	0·0557	0·0750	0·0570	0·0450
Interest and depreciation, at 8 per cent.	0·2132	0·1952	0·1852	0·2000	0·1030	0·1650
Total cost per unit	0·4429	0·4661	0·4851	0·4600	0·3950	0·3800

economies indicated in the paper could not be realised if it were necessary to retain a considerable percentage of the steam tractors, in use with their concomitant services for water, coal, cleaning, &c.

Before considering the probable costs of main-line locomotive operation, force will be given to the arguments to be used subsequently by a comparison of the costs of steam and electric suburban services. Suburban services worked at high schedule speeds with frequent stops are admittedly more costly to work than the average services on the main lines and branches of a railway; consequently, if a comparison be made between the average cost of operation per steam engine-mile on a typical main line and its branches and the cost of operation of suburban electrifications, the comparison will be of a very conservative nature by no means unduly favourable to electrical operation.

The average mileage per annum per steam locomotive in stock on the largest British system is approximately 26,000 miles per annum for passenger engines and 18,300 miles per annum for freight, the average being 21,100 miles per annum for the whole stock of 10,302 engines. The cost of repairs per engine-mile, which is much lower than the cost of repairs per train-mile, varies on the various sections of the railway from 4·5*d.* to 6·9*d.*, the average being 5·8*d.*

It must be borne in mind that these are averages and that large numbers of small tank engines and freight engines doing comparatively light work are included. The average mileage per annum is substantially less, and the cost of repairs per engine-mile is substantially heavier, for the passenger and freight engines employed, to haul the heavier trains on the main trunk routes which would be the first to be electrified.

The existing methods of railway accounting do not, however, yield in a complete form such figures as would enable a definite quantitative statement to be made as to the amount by which such repairs are higher. These variations in repair costs are mainly due to differences in the weight and speed of the trains hauled, in the physical characteristics of the section such as curves and gradients, and in the purity of the water supply, which affects the boiler maintenance.

The average mileage per annum per train on the various suburban electrifications in Great Britain varies from 47,320 miles to 36,296 miles. This mileage per electric train per annum really is analogous to the in his paper on "Financial Prospects of Railway Electrification" where a diagram is given showing the relative costs per train-mile for suburban steam, main-line steam, and suburban electric services, the relative costs in 1921 being 61·51*d.* and 42*d.* per train-mile respectively on the London, Brighton and South Coast Railway.

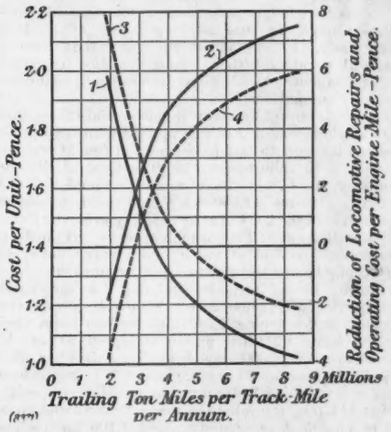
The above cost of steam-locomotive operation may now be compared with the probable cost if electric locomotives were substituted for main-line work. It is obvious on general principles that the result of this comparison should be much more favourable to electric operation than in the case of suburban traction dealt with above. The electrical equipment of the electric locomotives as a whole will be much less severely stressed on main-line work with comparatively long continuous runs than on the suburban work where the frequent stops and high accelerations cause severe stresses on motors, control, gears, and every other part of the equipment.

The result of experience on suburban lines of the London and North-Eastern Railway in this country, and on numerous electrified railways elsewhere, shows that the cost of repairs to an electric locomotive is from one-third to a quarter of that of a steam locomotive per engine-mile; and the same reduction in cost occurs in connection with subsidiary services rendered at steam sheds, such as cleaning, coaling, washing-out boilers, &c.

Owing to the simplicity of construction of the electric locomotive and the high degree of excellence of manufacture now attainable, it is probable that the average mileage obtainable between general repairs to the electric equipment will exceed 200,000 miles. The facts that the London and South-Western Railway on their suburban equipments and the London and North Eastern on their freight locomotives have never re-wound an armature or field coil during seven years' operation, and that the life of the modern commutator is at least 750,000 miles, are strong indications that the forecast given of the cost of repairs is correct.

The turning and changing of tyres and axle brasses, the renewal of brake blocks and the repairs to auxiliaries such as vacuum pumps, will be the principal causes of an interruption to continuity of service for any appreciable period. As neither these nor motor repairs will necessitate the return of the locomotive to the main repair shops, the capacity of these for steam-locomotive repairs will be considerably increased. The truth of the assertion is more evident if it be considered that 90 per cent. of the cost of steam locomotive repairs arises from the boiler or from crank-axle, wheels and frames due to the reciprocating and variable stresses imposed on these latter. Further, the experience of suburban electric services enables it to be said with absolute certainty that an electric locomotive can be available for traffic for 23 hours out of 24, and that a fortnightly examination of the electrical equipment will be sufficient.

The electric locomotive will therefore be capable of an annual mileage of 40,000 to 50,000 miles per annum, as compared with an average of about 20,000 miles for a steam locomotive; in fact, the mileage possibilities are only limited by the traffic requirements and the extent to which engine workings can be arranged to permit of continuous service. Universal experience indicates that one electric locomotive will at least perform the duty of two steam locomotives. At all times, and especially in foggy weather or at night, traffic movement will be greatly facilitated by the absence of any necessity for engines going out of service for coal, water, cleaning fires, tubes and smoke-boxes, or for turning. The liability to failure of the electric locomotive is also much less than that of the steam locomotive. It may be argued that the freedom of units from failure is counterbalanced by the possibility of failure of current supply, so that in the aggregate



Curve 1. Total cost per unit.
Curve 2. Reduction of locomotive repairs and operating cost due to electrification.
Curve 3. Total cost per unit. } Current at 0·5*d.* per unit
Curve 4. Reduction of locomotive repairs and operating cost due to electrification. } instead of 0·4*d.*, and cost of track equipment increased by 10 per cent.

the time lost in this respect will be the same if not greater. The reliability of the electrical supply equipment is so great to-day that the most modern suburban electrifications never suffer more than momentary interruptions due to circuit breakers operating.

The total cost of enginemen's wages will also be substantially reduced. Engine duties which represent time during which an engine is not in movement owing to its being required by its crew for examination, coaling, watering or cleaning fires, &c., account for 15 per cent. of the enginemen's hours in passenger service and 12 per cent. in freight service. These engine duties will be to a great extent eliminated with electric locomotives. The necessity for double crews on double-headed trains also disappears, and with this from 3 to 5 per cent. of the cost of enginemen's wages.

The further absence of any real need for a second skilled man on an electric locomotive, at least for shunting engines and multiple-unit trains, combined with the better utilisation of the machine which should be possible by rearrangement of the engine workings, should enable the total cost of enginemen's wages to be reduced by 33⅓ per cent.

Dealing with the remaining costs, that for water disappears, that for lubricants will be at least halved owing to the disappearance of cylinder oil and oil for reciprocating parts, and clothing and other stores will also be halved owing to the greater cleanliness of the electric locomotive.

On a typical suburban electrification which has been in operation for nearly 20 years the cost per train-mile was:—

Lubricants	0·033*d.*
Other stores and clothing	0·030*d.*
Other wages at sheds	0·640*d.*
	0·703*d.*

The comparative costs are shown in Table II, which

compares the costs on one of the former railway systems carrying heavy main-line traffic and the estimated costs of electric locomotive operation for the same traffic. On locomotive operation costs alone, excluding fuel, and almost quite independently of the density of traffic, there should be an economy of nearly 10*d.* per engine-mile. The average density of traffic, which seriously affects the cost of the electric current supplied to the locomotive, would, however, preclude the realisation of such a large economy in practice.

Before passing to the consideration of the cost of energy and how this modifies the very real economy effected by the electric tractor as a substitute for the steam tractor, some other points must be dealt with.

The weight of the main-line passenger and freight trains in this country is comparatively small. On a certain 100-mile section of the London, Midland and Scottish Railway with heavy gradients, an examination of the weights of the heavy through trains at the heaviest period of the year showed an average of 275 tons behind the locomotive drawbar per passenger train, and of 410 tons per goods train; the maximum weight of passenger train only slightly exceeded 400 tons and was hauled by two engines. With rare exceptions the heaviest passenger trains do not exceed 350 tons, or goods trains 800 tons, trains of greater weight being almost invariably hauled by two locomotives. The combined maximum tractive effort of two steam locomotives such as are commonly used for these trains would be 16 tons for the passenger train, and 21 tons for the freight train, and on occasions the combination might be such as to give 20 and 25 tons respectively. It is evident, therefore, that from a practical standpoint there is no objection to single electric locomotives with initial drawbar pulls analogous to these combinations.

It is not realised by many engineers and others that the electric locomotive can be applied with both profit and facility to both fast passenger and freight services as well as to suburban work. The General Electric Company in U.S.A. have recently completed and tested a 120-ton, 1,500-volt, high-speed passenger locomotive of the 2-C-C-2 articulated type for the Paris-Orleans Railway. This machine easily attained its guaranteed speed of 81 m.p.h. and a maximum speed of 105 m.p.h. was sustained during the final runs.

Brown, Boveri are also building for the Paris-Orleans Railway some 2-D-2 1,500-volt locomotives capable of developing 2,580 h.p. for one hour, their weight being 92 tons, maximum speed 81 m.p.h., haulage capacity 600 tons behind the drawbar up a 1 in 75 gradient at 40 m.p.h.; also a C-C freight locomotive developing 3,600 h.p. for one hour, its weight being 114 tons (all adhesive weight), maximum speed 50 m.p.h., haulage capacity about 1,100 tons behind the drawbar up a 1 in 75 gradient at 25 m.p.h.

Proceeding to consider the comparative costs of fuel and current the following basis has been taken:—Generation, three-phase at 11,000 volts; overhead three-phase transmission at 44,000 to 66,000 volts according to distance; conversion by mercury arc rectifier to 1,500 volts (d.c.), and distribution at this voltage by third rail, with overhead equipment in stations and station yards.

The author has therefore endeavoured to arrive at a generally applicable graph expressing the cost of energy for electric traction as compared with steam, in pence per locomotive-mile, the energy being that required at the tread of the wheels of the tractor for propelling both the tractor and the train hauled by it. (See Fig. 1, page 449.)

The expression "gross ton-miles" refers to the total weight of tractor, train and train load; and "trailing ton-miles" to the total weight of train and train load behind the tractor. The cost of coal for locomotive purposes has been assumed to be 23s. per ton delivered to the locomotive depot in wagons, equivalent to 7·40*d.* per engine-mile at 60 lb. of coal per mile, and the cost of a high-tension unit at the 44,000 volt busbars at the power station to be 0·40*d.* This figure for the price of coal is a conservative one.

It will be convenient at this point to refer to the load factor which would probably be obtained for such a supply, the load factor being defined as the ratio of the total units delivered to the high-tension feeders per annum to the maximum hourly load multiplied by 8,760 (the number of hours in a year).

The load factor on the suburban electrifications of the London Midland and Scottish Railway, where there is practically no load from 12 midnight to 6 a.m. and where the load diminishes between 10 a.m. and 4 p.m. to between 66 per cent. and 50 per cent. of its rush-hour value, is of the order of 40 per cent. In all these cases the load factor is improved by the use of batteries operating in parallel with the converter plants, but tests made with the batteries eliminated show that the resultant load factor is only reduced by about 5 per cent. by their absence.

Examination of the actual electrical load to be anticipated on a section of straightforward main-line double track with a density of five million trailing ton-miles per track-mile per annum indicates a load factor of about 50 per cent. It may be taken as a postulate that any length of main line worth electrifying will have a load factor of not less than this, and that where goods traffic, and particularly mineral traffic, predominate the load factor will run up to as high as 70 per cent. These high load factors will naturally result in a low coal consumption and a low cost per unit whether the supply be generated at a railway company's own power station or whether it be purchased.

Table III shows in the first four columns some typical costs of generation in economical stations in Great Britain with load factors varying between 25 per cent. and 30 per cent. These costs have been brought to a common basis, which assumes a rate of 8 per cent. for interest on capital and depreciation combined and is further based on coal at 15*s.* per ton. It will be seen that the cost of a high-tension unit delivered to the feeders is about 0·46*d.*, the average coal consumption of these stations being about 1·9 lb. per unit. The generating costs of a typical power station producing current for suburban traction, and of an assumed railway generating station working on the load produced by a main-line electrification, are also given on the same basis. From the load factor obtainable from a main-line electrification, and from consideration of these results and those obtained at Blackburn, the probable cost per high-tension unit may be assumed not to exceed 0·40*d.*

Table IV shows the average yearly efficiencies of transmission and conversion assumed, and these may be compared with those actually obtained in practice on the suburban electrifications.

The cost per high-tension unit of 0·4d. is increased therefore to 0·6d., on the score of efficiency alone, for the equivalent in energy of 1,000 watt-hours at the tread of the wheels. To obtain the actual cost of this

TABLE IV.—*Efficiencies of Transmission.*

—	Average of existing suburban electrifi-cation.	Author's estimate for a main-line elec-trification	Mr. Parodi's estimate.	Mr. Roger Smith's estimate.
	Per cent.	Per cent.	Per cent.	Per cent.
H.T. transmission ..	97	94·5	95*	95
Transformation and conversion ..	91	92	83	85
L.T. transmission ..	90	90	95	90
Efficiency from loco. shoe to tread of wheel	85	85	85	85
Overall efficiency ..	67·5	66·5	63·6	60

* Assumed by author.

energy the total units used must bear the further cost of operation, maintenance, interest and depreciation of the high-tension and low-tension transmission systems and the converting plant.

It may be assumed without any very great error that the low-tension 1,500-volt distribution system will for any given 100 miles of route remain constant whatever the density of traffic. Considerations of life of equipment and of stability and strength will dictate the use of a fairly large conductor, the substation spacing and the size of substation equipment being varied to suit the density of traffic and varying almost directly as that density.

The cost of the high-tension transmission, if overhead, will also remain approximately constant per mile of route where it is derived from a single generating station supplying a division of main line from 50 to 150 miles in length, the voltage being varied to some extent to suit the load and the distance of transmission.

The watt-hours per ton-mile required for the types and weights of trains hauled on sections of British main line carrying dense traffic are not easily determined, nor are there any general statistics available as to the coal consumption per ton-mile, either gross or trailing, for steam locomotives.

The L M S Railway have, however, within the last two years carried out a number of dynamometer car tests with main-line trains. The dynamometer car is fitted with an integrator which records the horse-power-hours at the drawbar, and it is possible from these records, and from the published results of others, to deduce a figure for the watt-hours per trailing ton-mile which would be used by an electrically hauled train and for the coal per ton-mile which would be used by a steam-hauled train for a general main-line service. The records have been made with very heavy and fast trains on routes with heavy gradients, and with both passenger and goods trains. The results are therefore probably on the high side.

The average figures of the tests are as follows:—

Max. drawbar h.p. recorded for one locomotive	1,232
Max. speed on the level or on up gradient, m.p.h.	65
Lb. of coal per ton-mile gross, including all losses	0·175
Horse-power-hours per trailing ton-mile	0·036
Equivalent watt-hours per trailing ton-mile	26·8
Lb. of coal per drawbar h.p.-hour, excluding shed duties	4·52
Lb. of coal per drawbar h.p.-hour, including shed duties	5·89

In regard to the figure of 26·8 watt-hours per ton-mile, if the gross weight of train be taken at 320 tons, Mr. Roger Smith uses the figure of 26 and Mr. Parodi estimates it at about 30.

Figures taken from tests on other routes in Great Britain, given in Mr. Hughes's paper before the Institution of Mechanical Engineers on superheating and compounding, tend to show, allowing for the fact that all the figures examined are test results made presumably with engines in first-class condition with picked drivers, that the figure of 0·175 lb. of coal per ton-mile used as the basis of calculating gross train weight is probably a fair approximation to the truth.

A rough check on the accuracy of these figures is given by multiplying the coal per ton-mile thus experimentally obtained by the estimated gross ton-miles for a 100-mile section of main line carrying traffic very similar to that of the tests. The annual coal consumption thus obtained only differed by 1·6 per cent. from the actual coal consumption for the year 1922.

(To be continued.)

CATALOGUES.

Roller Bearings.—A further sheet giving illustrations and particulars of their roller bearings, housings, &c., is to hand from the Empire Roller Bearing Company, Limited, Thornbury, Bradford.

Welding Rods.—A list of rods and fluxes for welding cast-iron, with some 16 pages of useful information relating to the process, is to hand from the Suffolk Iron Foundry, Limited, Stowmarket.

Cables, Electrical Apparatus, &c.—The British Insulated and Helsby Cables, Limited, Prescot, Lancs, have sent us a list of the products of their works at Prescot, Helsby, and Huyton Quarry and of their offices and agents at home and abroad.

Steam Wagons.—Lighting up the fires of steam wagons by high-pressure gas is provided for by apparatus made by Messrs. James Keith and Blackman Company, Limited, 27, Farringdon-avenue, London, E.C. 4, who have issued a leaflet explaining the method and giving particulars of costs.

Cranes.—A catalogue received from Messrs. John H. Wilson and Co., Limited, Birkenhead, deals with steam cranes for contractors, dockyards, shipbuilders, &c., steam shunting cranes, steam grab cranes, electric cranes, and electric shunting cranes. Several types of each class are illustrated.

Steam Fittings.—Messrs. Princeps and Co., Wentworth Chambers, Pinstone-street, Sheffield, have issued catalogues of two separate fittings for extracting oil and water, respectively, from steam. Each fitting is made in a series of standard sizes for connection to pipes ranging from 2 in. to 24 in. in diameter.

Grinding Mills.—Messrs. Hind and Lund, Limited, Preston, have sent us a leaf catalogue of their three-roll mill for grinding white lead, paints, colours, soap, chocolate, &c. Three standard sizes are made, which are capable of grinding from 2 to 7 tons of lead a day. Rolls are supplied in chilled iron or granite.

Leather Goods, &c.—A four-page circular issued by Messrs. Ira Stephens, Limited, Whitelands Tannery, Ashton-under-Lyne, gives a concise description of many leather and raw-hide articles for use in engineering work, with the commercial names of varieties and qualities. Similar notes relating to hair and cotton belting and asbestos are also given.

Mill Machinery.—A comprehensive catalogue extending to 90 quarto pages received from Messrs. J. Harrison, Carter, Limited, Dunstable, whose London office is at 12, Mark-lane, E.C., deals with disintegrators and machinery for grinding, crushing, sifting, drying, packing weighing, elevating, conveying, &c.; it also includes particulars of shafting, bearings, gears, &c.

Timber Drying.—The compartment, progressive and double-duct systems of timber drying are described in a catalogue of the plant required for these processes made by Messrs. James Keith and Blackman Company, Limited, 27, Farringdon-avenue, London, E.C. 4. In all cases hot moist air is employed, and the fittings and methods of operation are adapted to suit the quantity of timber to be dealt with.

Acid Pumps.—Messrs. Meldrums, Limited, Timperley, near Manchester, have sent us a catalogue of centrifugal acid pumps constructed of a special metal, which the makers guarantee to be proof against sulphuric, nitric and acetic acids of any strength and at any temperature. The pumps are arranged for belt or direct-coupled electric motor drive and are made in standard sizes, with connections ranging from 1 in. to 6 in. in diameter.

Shop Fittings.—A new edition of their catalogue for the current year is to hand from Messrs. S. W. Francis and Co., Limited, 64, Gray's Inn-road, London, W.C. 1. The chief products of this firm are rolling shutters in steel or wood, metal shop fronts, name plates, roller blinds, collapsible steel gates, wrought-iron grids, &c. The catalogue includes particulars of a large range of patterns in metal-covered bars and beadings and metal sections, as well as of large sign letters in several styles.